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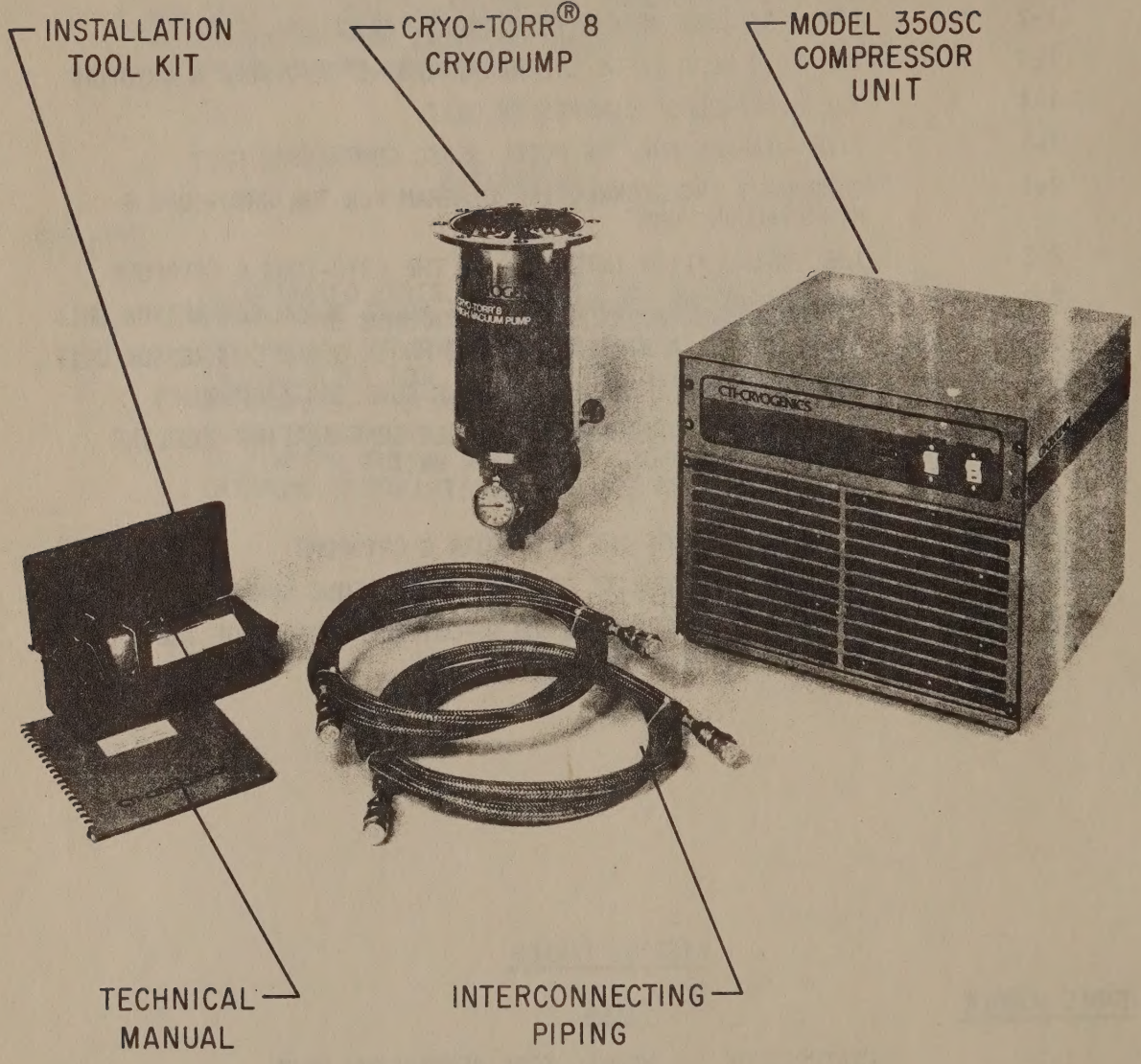


FIGURE 1-1. THE CRYO-TORR® 8 HIGH-VACUUM PUMP

CHAPTER 1
INTRODUCTION

1.1 GENERAL

The CRYO-TORR(R) 8 High-Vacuum Pump provides fast, clean pumping of all gases in high-vacuum applications. This high-vacuum pump (see Figure 1-1) consists of the CRYO-TORR 8 Cryopump, the Model 350SC Compressor Unit, interconnecting piping, and an installation tool kit.

The high-vacuum pump, which uses helium as the refrigerant, is designed to interface with many kings of apparatus used in high-vacuum technology, including ion implanters, particle accelerators, sputtering systems, and deposition systems. Along with a pumping speed of 1,500 liters per second for air, this pump also offers high reliability and cleanliness for operation in a wide variety of applications in science and industry.

1.2 DESCRIPTION OF COMPONENTS

1.2.1 CRYO-TORR 8 Cryopump (see Figure 1-2 and also Figure A-1 of Appendix A)

The CRYO-TORR 8 Cryopump, which is identified throughout this manual as the cryopump, consists principally of the Model 21 Cold Head (19, Figure 1-2), a vacuum housing (17), and two condensing arrays (1,2), a cryo-adsorbing array (3), and a radiation shield (4) that are installed in the vacuum housing. The cold head (see Figure 1-3) is rigidly attached to the vacuum housing and is used to cool the three arrays.

The cold head is connected by interconnecting piping (see Figure 1-1) to a remote helium-gas compressor unit (see Figure 1-4). The power switch (2, Figure 1-4) that controls the cold head (and hence the cryopump) is located on the compressor unit.

The condensing and cryo-adsorbing arrays are attached to the cold-head cylinder (5, Figure 1-2) with screws to facilitate easy removal. Gases present in the User's vacuum system are removed by either cryo-condensing or cryo-adsorbing them upon these arrays.

1.2.1.1 Vacuum Housing and Associated Arrays (see Figures 1-2 and A-1)

The 80K condensing array (1, Figure 1-2) freezes out water and hydrocarbon vapors. The 15K condensing array (2) cryo-condenses nitrogen, oxygen, and argon. In addition, helium, hydrogen, and neon are cryo-adsorbed on the charcoal of the 15K cryo-adsorbing array (3). The temperature of the cold station (9) to which the two 15K arrays are attached is measured by a means of a hydrogen-vapor-pressure gauge (14). (The CRYO-TORR(TM) Vacuum-Pump Temperature Indicator is available as an optional accessory to read that temperature when the cryopump is equipped with the optional silicon-diode temperature sensor.)

The 6-inch ANSI mounting flange (13) of the vacuum housing (17) contains an O-ring groove that accomodate a #2-172 Viton O-ring. (The CRYO-TORR 8 Cryopump is also available with a 10-inch-OD metallic-seal mounting flange.) This flange is the interface with the User's vacuum system.

Note: If the mating flange of the User's vacuum system also has an O-ring groove, it may be necessary to interpose a double-sided, flat-faced spacer ring between the two flanges.

The vacuum housing contains an accessory port (29), which can be modified so that a roughing valve and/or a vacuum gauge can be connected to it. The accessory-port cover (30) is sealed to the vacuum housing by an O-ring, and can be modified to accept a 3/4-inch (maximum) OD tube. The accessory port, when fitted with a roughing valve, can be used for re-evacuating the vacuum housing after regeneration (see Chapter 4).

WARNING: DO NOT INSTALL A HOT-FILAMENT GAUGE (ION GAUGE) ON THE CRYOPUMP SIDE OF THE HI-VAC VALVE (SEE SECTION 2.4). IT COULD BE A SOURCE OF IGNITION FOR FLAMMABLE GASES.

The vacuum housing also contains a relief valve assembly (18), which will open at 2 to 3 psig to prevent overpressure that might develop during regeneration as the condensed gases vaporize.

1.2.1.2 Cold Head (see Figures 1-2 and 1-3)

The function of the cold head (19, Figure 1-2) is to produce continuous closed-cycle refrigeration at temperatures that, depending upon the heat load imposed, are in the range of 77K to 100K for the first-stage cold station (7) and in the range of 12K to 20K for the second-stage cold station (9).

Note: Refer to Appendix E for an explanation of the principles of operation by which the cold head and compressor unit employed in the CRYO-TORR 8 High-Vacuum Pump achieve cryogenic levels of refrigeration.

The cold head has three major components: the drive unit (23), the cylinder (5), and the displacer-regenerator assembly (28), which is located inside the cylinder.

The drive unit consists of the following subassemblies: the drive motor (24), the crankcase (26), and the drive mechanism (25), which is located inside the crankcase. The drive mechanism is attached to the drive-motor shaft. As this shaft rotates, the drive mechanism imparts reciprocating motion to the displacer-regenerator assembly, while at the same time operating the inlet and exhaust valves. This controls the flow of helium gas through the cold head.

The drive motor is a direct-drive, constant-speed motor that operates at 72 rpm on 60-Hz power and at 60 rpm on 50-Hz power. It is enclosed within a sealed housing and is attached to the crankcase. The motor housing has two connectors: one is the electrical power connector (22), through which power is supplied; the other is the helium-gas return connector (21).

The incoming high-pressure helium gas from the compressor unit enters the crankcase through the helium-gas supply connector (20). The gas then passes through the inlet valve and into the displacer-regenerator assembly. The return (exhaust) flow passes from the displacer-regenerator assembly, out through the exhaust valve and into the crankcase, through the motor housing, and thence through the helium-gas return connector (21) to the compressor unit. The expansion of helium gas through the displacer-regenerator assembly provides cooling at two discrete temperatures (at the first- and second-stage cold stations).

1.2.2 Compressor Unit (see Figure 1-4)

The compressor unit consists of the following major components: a hermetic compressor pump, a cooling system, an oil-injection system, an oil separation system, and an adsorber. In addition, the compressor unit contains instrumentation, controls, and protective devices.

The compressor unit also houses the electrical-control-chassis components required to operate the compressor unit and the cryopump. (The electrical-control panel and chassis located at the front of the compressor unit can be removed and mounted at a separate location; see Section 2.6). A grounded input power cable (4, Figure 1-4) and a cold-head power cable (5) are provided as integral parts of the compressor unit.

> Note: Refer to Appendix B for information relating to the electrical circuits of the compressor unit.

The compressor unit is designed for unattended operation. A helium-supply pressure gauge (7), an elapsed-time meter (3), and two power switches (1, 2) provide all of the needed instrumentation. Functional descriptions of the controls, indicators, and other features of the compressor unit are given in Table 1-1.

1.2.2.1 Gas and Oil Flows in the Compressor Unit (see Figure 1-5)

The low-pressure return-flow helium from the cold head in the cryopump enters the compressor unit through the gas-return connector (8, Figure 1-4). After passing through a check valve, the helium goes to the compressor pump. The check valve prevents any of the particulate oil that has been injected into the helium return line to the compressor pump for cooling purposes from backstreaming into the cold head.

The helium-and-oil mixture passes through the rotary-vane compression device depicted in Figure 1-5 and exits as the "1st discharge from the pump." The rotary vane is mounted (with a slip fit) on a vertical shaft that is driven by an electric motor located directly below the vane. As the shaft rotates, the vane (a) rotates within a cylinder that is located eccentrically with respect to the shaft and (b) slides back and forth with respect to the shaft. The return-flow helium enters the bottom of the off-center cylinder and after being compressed by means of the arrangement described discharges from the cylinder through a reed-type valve located in the top of the rotary vane compression device.

The hot oil-and-helium mixture discharged from the rotary-vane compression device passes through the No. 1 gas-to-air heat exchanger, where it is cooled by the fan assembly. As the mixture cools, much of the oil in it condenses. The high-pressure mixture passes through the compressor-pump housing where the oil drops separate from the helium. Oil drops into the sump of the pump and the helium removes heat from the electric drive motor. The gas stream then passes through the No. 2 gas-to-air heat exchanger where the cooling reduces the helium temperature and condenses the remaining oil particles. This particulate oil is removed from the helium by the oil separator. The 350-psig system relief valve in the oil separator assembly

protects against overpressure. The separated oil is returned to the compressor pump after passing through a filter and an orifice. The orifice minimizes the bypassing of helium along with the separated oil. The filter prevents the orifice from becoming clogged with any foreign matter.

As it leaves the oil separator, the helium gas stream is free of particulate oil but does contain a minute quantity of oil-vapor particles. These particles are removed by the charcoal bed in the adsorber. After every 10,000 hours of compressor-unit operation, the adsorber must be replaced.

Because the pressure inside the housing of the compressor pump is that of the high-pressure supply gas, oil from the sump of the compressor pump is forced through the oil-to-air heat exchanger to cool the oil before it is mixed, for cooling purposes, with the low-pressure return-flow helium from the cold head. The high differential pressure across the metering orifice converts the oil on the high-pressure side (the sump side) of the orifice to minute particles of oil on the low-pressure side (the rotary-vane side). The metering orifice controls the rate of particulate-oil flow so as to provide optimum cooling of the rotary-vane compression device. The filter associated with the metering orifice prevents the orifice from becoming clogged with any foreign matter.

1.2.2.2 Pressure Regulation in the Compressor Unit (see Figure 1-5)

Except for the effect of the orifice in the oil return line from the oil separator, there is no mechanical regulation of pressure in the compressor unit. The compressor unit may be considered to be a fixed-speed, fixed-displacement pump that operates at an essentially constant temperature. The return and supply pressures of the compressor unit are thus functions of the mass-flow rates from and to the cold head.

Since the cold head also is a fixed-displacement device, the mass flow within it is a function of the temperature of the gas stream. When the cold head is first started, it is warm; therefore, the density of the helium is low. Consequently, immediately after start-up the mass flow is low. Under these conditions, the compressor-unit return pressure becomes low and the compressor-unit supply pressure becomes high. The differential-pressure relief valve in the compressor unit opens when the differential pressure exceeds 185 psi. It then passes gas to the low-pressure side, thus reducing high-stress loads on the compressor pump. It also prevents the compressor unit from operating in a "blanked-off" condition due to (a) failure of the cold head or (b) disconnected interconnecting piping between the cold head and the compressor unit.

As the cold head cools down, the density of the gas within it increases. Under these conditions, the supply pressure progressively decreases and the return pressure progressively increases until the differential-pressure relief valve closes and a stable operating temperature is reached.

1.3 SPECIFICATIONS

The specifications for the compressor unit and cryopump of the CRYO-TORR(R) 8 High-Vacuum Pump are listed in Table 1-2.

1.4 CROSSOVER PRESSURE

The pressure in the User's vacuum chamber when the Hi-Vac valve (the high-vacuum isolation valve in the User's vacuum system; see Section 2.4) is opened (see Section 3.3) is called the crossover pressure. More specifically, the crossover pressure is defined as the pressure in the User's vacuum chamber at which the change (crossover) from rough-pumping the User's vacuum chamber with the User's rough-pumping system to high-vacuum-pumping that chamber with the cryopump takes place. The following equation can be used to determine the maximum permissible crossover pressure.

$$\text{Maximum Permissible Crossover Pressure} = \frac{\text{Maximum Gas Burst that can be Handled}}{\text{Volume of the User's Vacuum Chamber}}$$

The CRYO-TORR 8 High-Vacuum Pump can handle a maximum gas burst of 150 torr-liters from the User's vacuum chamber at crossover, if the composition of the residual gas in the User's vacuum chamber is primarily air. Thus, for example, with a typical 18-inch-diameter x 30-inch-high bell jar, which has a volume of about 100 liters, the maximum permissible crossover pressure would be

$$\frac{150 \text{ torr-liters}}{100 \text{ liters}} = 1.5 \text{ torr} = 1{,}500 \text{ microns}$$

Note: If the composition of the residual gas in the User's vacuum chamber is not known, it is wise to assume (in applying the above equation for determining the maximum permissible crossover pressure for the initial start-up and cooldown) that the maximum gas burst that can be handled is well below 150 torr-liters. Then, during subsequent crossovers, gradually increase the crossover pressure while noting the response of the hydrogen-vapor-pressure gauge. When the Hi-Vac valve is opened, the hydrogen-vapor-pressure gauge will peak. This peak should not exceed 25 psia (22K). This is to ensure that the 15K and 80K condensing arrays do not warm above the point at which they would release previously condensed gases that have been frozen onto these arrays.

1.5 TEMPERATURE INDICATION

When the second-stage cold station (9, Figure 1-2) is at a temperature of 24K or below, its temperature may be measured by means of the hydrogen-vapor-pressure gauge on the cryopump. Use the data given in Table F-1 of Appendix F to convert a reading of the hydrogen-vapor-pressure gauge (in psia) to temperature (in Kelvin).

The CRYO-TORR™ Vacuum-Pump Temperature Indicator is available as an optional accessory to read the temperature of the second-stage cold station when the cryopump is equipped with the optional silicon-diode temperature sensor.

TABLE 1-1. FEATURES OF THE MODEL 350SC COMPRESSOR UNIT

FEATURE	FIGURE 1-4 ITEM NO.	FUNCTION
Compressor-Unit "ON-OFF" Switch (SW1)	1	Starts and stops the compressor pump and cooling fan. The switch contains a built-in circuit breaker to protect the system from excessive current drain.
Cold-Head "ON-OFF" Switch (SW3)	2	Starts and stops the cold-head drive motor, once the compressor-unit "ON-OFF" switch has been activated.
Elapsed-Time Meter (ETM)	3	Indicates, in hours, the cumulative compressor-unit operating time.
Input Power Cable	4	Connects the compressor unit to its power source.
Cold-Head Power Cable	5	Provides power to the cold-head drive motor.
GAS CHARGE Fitting	6	Used to adjust the compressor unit charge pressure. When additional pressure is required, a source of helium gas may be connected to this fitting -- which is located on the supply (high)-pressure side of the compressor unit.
Helium supply PRESSURE gauge	7	Indicates the pressure of the helium supply gas.
Helium RETURN GAS connector	8	Self-sealing coupling for connecting the helium return line from the cryopump to the compressor unit.
Helium SUPPLY GAS connector	9	Self-sealing coupling for connecting the helium supply line from the compressor unit to the cryopump.
Safety interlock switch (SW2)		Ensures that the compressor unit can not be inadvertently turned on when its cover is not in place.

Note: The symbol designations given in parentheses for the electrical controls and indicators are those used on the electrical schematic diagram shown in Figure B-1 of Appendix B.

TABLE 1-2. SPECIFICATIONS FOR THE CRYO-TORR(R) 8 HIGH-VACUUM PUMP

MODEL 350SC COMPRESSOR UNIT

Dimensions (approximate)	
Length	19.6 inches (498 mm)
Width	19.5 inches (495 mm)
Height	16.8 inches (426 mm)
Weight (approximate)	140 pounds (63.5 kg)
Power requirements	
Part Number D8032028G1	208 or 230 VAC, 60 Hz, single phase; 11 amps max while unit is running. The recommended operating voltage range is 198 volts (minimum) to 253 volts (maximum).
Part Number D8032028G2	200 or 220 VAC, 50 Hz, single phase; 11 amps max while unit is running. The recommended operating voltage range is 190 volts (minimum) to 230 volts (maximum).
	Notes: (1) Each recommended voltage range applies to the voltage across the "run" terminals of the compressor-pump motor (see Figure B-1).
	(2) The nominal operating power requirement for each unit is 1.5 kW.
System Pressures	
Static	250 psig (at ambient temperature)
Operating	285 psig (at operating temperature)
Ambient-temperature Operating Range	60°F to 100°F (16°C to 38°C)
Interface	
Length of power supply cable	10 feet (3m)
Length of cold-head power cable	10 feet (3m)
Power-supply-cable connector	2-pole, 3-wire, grounded, NEMA 6-15R
Gas-supply connector	1/2-inch self-sealing coupling
Gas-return connector	1/2-inch self-sealing coupling
Adsorber service schedule	Replace at 10,000 hours of use

TABLE 1-2. SPECIFICATIONS FOR THE CRYO-TORR(R) 8 HIGH-VACUUM PUMP (cont.)

CRYO-TORR(R) 8 CRYOPUMP	
Weight (approximate)	45 lbs (20.4 kg)
Power requirement	150 VAC, 1Ø (supplied from the compressor unit)
Instrumentation	
Hydrogen-vapor-pressure gauge charge pressure at 70°F (21°C) and 14.7 psi (1 kg/cm)	80 ± 2 psia
Interface	
Gas-supply connector	1/2-inch self-sealing coupling
Gas-return connector	1/2-inch self-sealing coupling
Pumping speeds	
Water	4,000 liters/second
Air	1,500 liters/second
Hydrogen	2,000 liters/second
Argon	1,200 liters/second
Argon throughput (maximum)	700 scc/minute; 8.9 torr-liters/second. (A throttling valve is required for pressures exceeding $5x10^{-3}$ torr.)
Orientation	The cryopump may be operated in any orientation.

LEGEND FOR FIGURE 1-2

Item Number	Description
1	80K Condensing Array (First-Stage Array Assembly)
2	15K Condensing Array (Second-Stage Array Assembly)
3	15K Cryo-Adsorbing Array (also known as the 15K Inner Charcoal Chamber)
4	80K Radiation Shield
5	Cold-Head Cylinder
6	First-Stage Cylinder
7	First-Stage Cold Station
8	Second-Stage Cylinder
9	Second-Stage Cold Station
10	O-Ring Between the Drive Unit - Displacer Assembly and the Vacuum Housing
11	Protective Cover
12	Inlet-Seal O-Ring
13	Mounting Flange
14	Hydrogen-Vapor-Pressure Gauge (Thermometer)*
15	End Plate
16	Shell
17	Vacuum Housing
18	Relief Valve Assembly
19	Cold Head (Refrigerator Unit)
20	Helium-Gas Supply Connector
21	Helium-Gas Return Connector
22	Electrical Power Connector for the Cold Head
23	Drive Unit
24	Drive Motor
25	Driver Mechanism
26	Crankcase
27	Sight Glass
28	Displacer-Regenerator Assembly
29	Accessory Port
30	Accessory-Port Cover

*The CRYO-TORR 8 Cryopump is also available with a silicon-diode temperature sensor.

NOTES:

1. See also Figure A-1 in Appendix A, which shows the CRYO-TORR(R) 8 Cryopump disassembled into its major component assemblies.
2. The cold-head cylinder (5), which consists of items 6 through 9, contains the two-stage displacer-regenerator assembly shown in Figure 1-3.
3. The vacuum housing, which consists of items 5, 13, 15, 16, and 18, appears in Figure A-1 of Appendix A as item 34.
4. The drive unit (23) consists of items 24 through 27.
5. The displacer-regenerator assembly (28), which is located inside the cold-head cylinder (5), consists of two displacer-regenerator stages (see Figure 1-3).
6. The drive unit (23) and the displacer-regenerator assembly (28), the helium-gas connectors (20) and (21), and the electrical power connector (22), constitute the drive unit-displacer assembly shown in Figure 1-3 and also as item 26 in Figure A-1 of Appendix A.
7. The cold head (19) consists of items 5, 20, 21, 22, 23, and 28; or, stated another way, the cold head consists of the drive unit-displacer assembly shown in Figure 1-3 plus the cold-head cylinder (5).

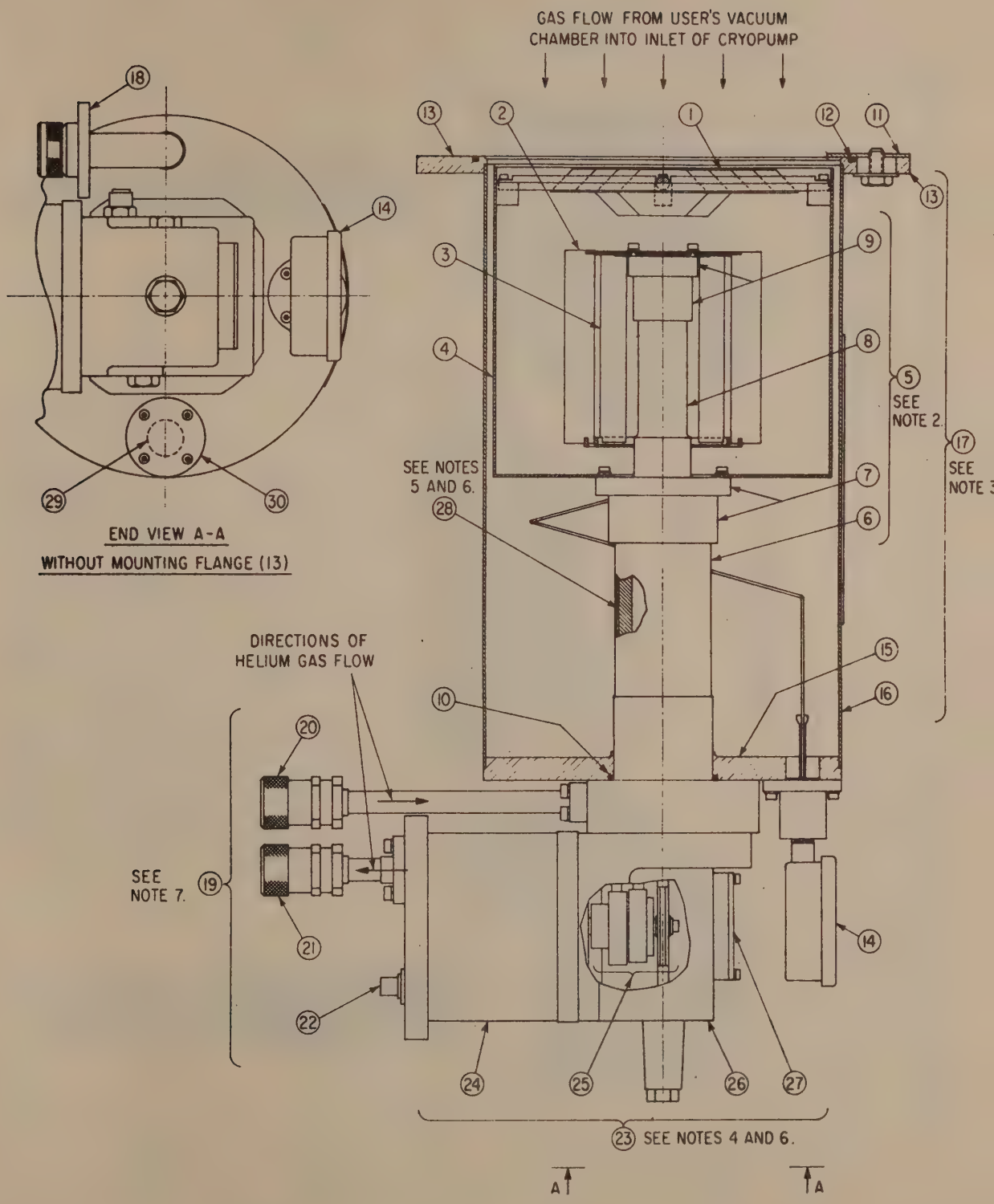
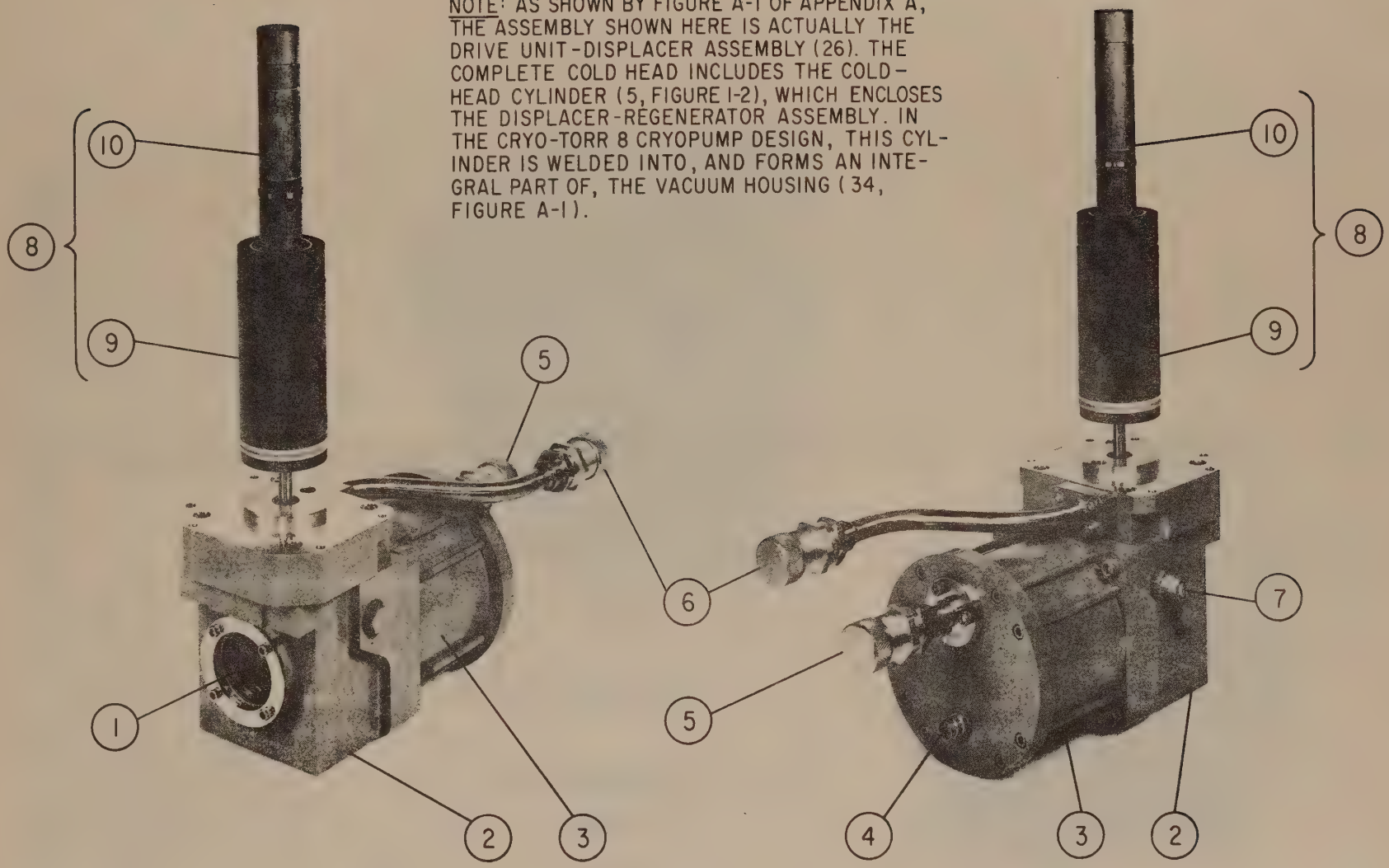


FIGURE 1-2. CROSS SECTION OF THE CRYO-TORR® 8 CRYOPUMP

LEGEND FOR FIGURE 1-3

Item Number	Description
1	Sight Glass
2	Crank Case (houses the drive mechanism)
3	Drive Motor
4	Electrical Power Connector
5	Helium-Gas Return Connector
6	Helium-Gas Supply Connector
7	Pressure Relief Valve
8	Displacer-Regenerator Assembly
9	First-Stage Displacer-Regenerator
10	Second-Stage Displacer-Regenerator


NOTE: AS SHOWN BY FIGURE A-1 OF APPENDIX A, THE ASSEMBLY SHOWN HERE IS ACTUALLY THE DRIVE UNIT-DISPLACER ASSEMBLY (26). THE COMPLETE COLD HEAD INCLUDES THE COLD-HEAD CYLINDER (5, FIGURE 1-2), WHICH ENCLOSES THE DISPLACER-REGENERATOR ASSEMBLY. IN THE CRYO-TORR 8 CRYOPUMP DESIGN, THIS CYLINDER IS WELDED INTO, AND FORMS AN INTEGRAL PART OF, THE VACUUM HOUSING (34, FIGURE A-1).
10
8
9
5
6
1
2
3
A. FRONT VIEW
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7
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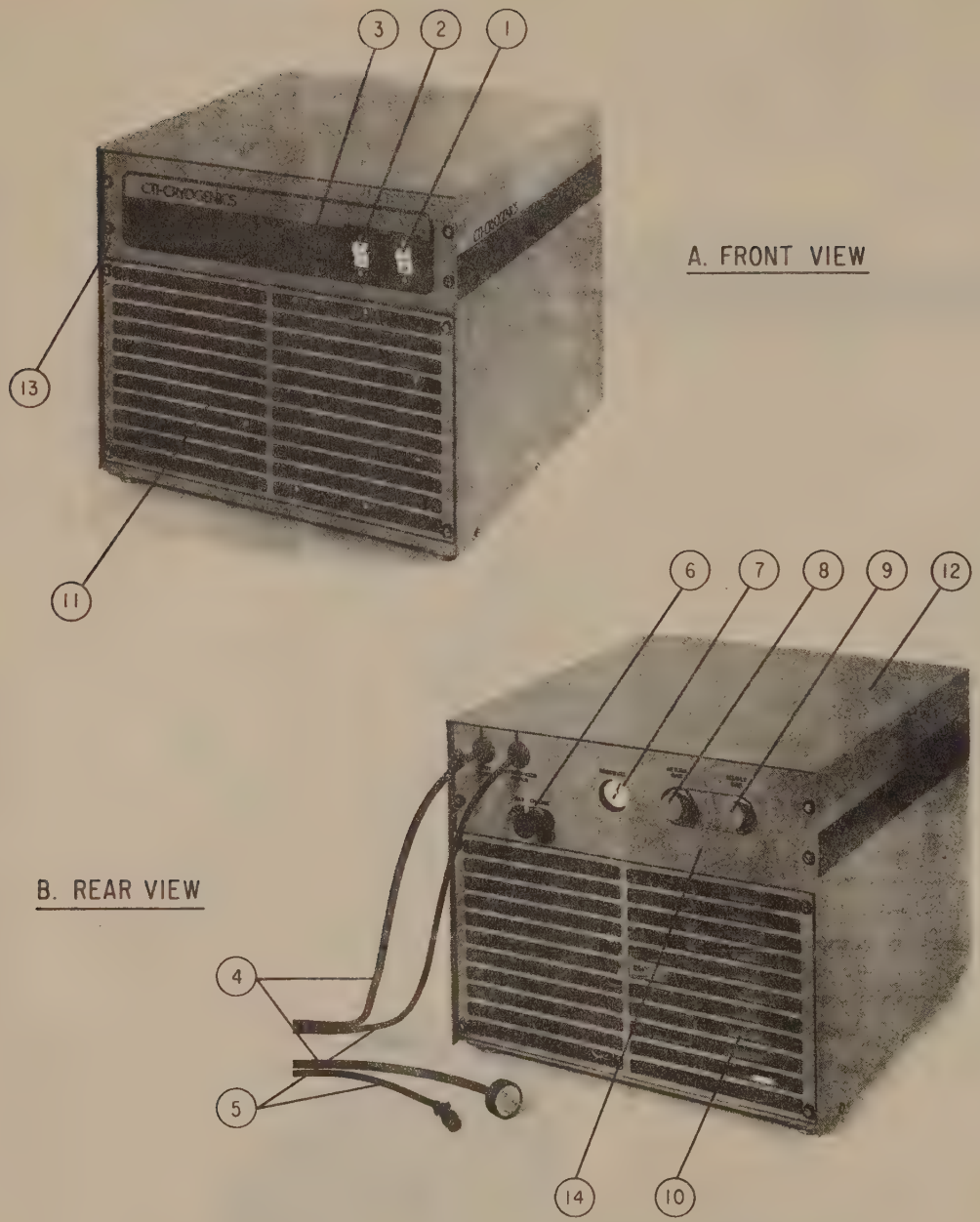
4
3
2
B. REAR VIEW

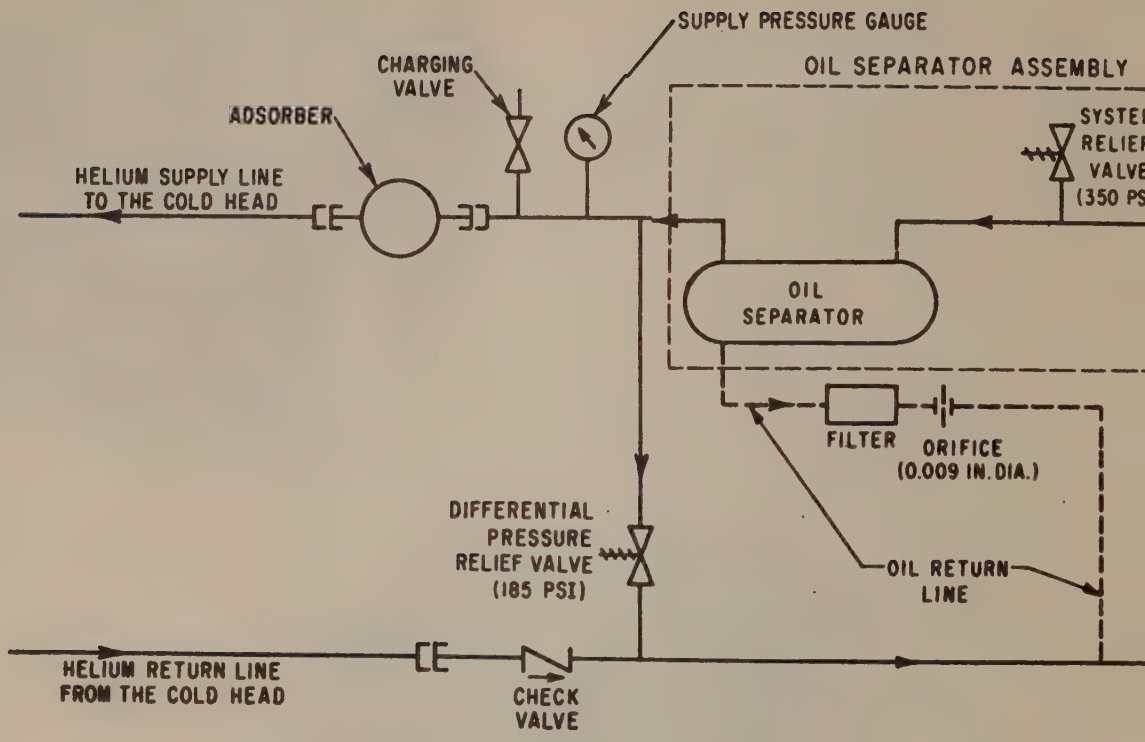
FIGURE 1-3. THE COLD HEAD (LESS CYLINDER) OF THE CRYO-TORR® 8 CRYOPUMP



LEGEND:

1. COMPRESSOR-UNIT "ON-OFF" SWITCH
2. COLD-HEAD "ON-OFF" SWITCH
3. ELAPSED-TIME METER (ETM)
4. INPUT POWER CABLE
5. COLD-HEAD POWER CABLE
6. GAS CHARGE FITTING
7. SUPPLY PRESSURE GAUGE
8. GAS-RETURN CONNECTOR
9. GAS-SUPPLY CONNECTOR
10. REAR GRILLE
11. FRONT GRILLE
12. COVER
13. FRONT PANEL
14. REAR PANEL

FIGURE 1-4 THE MODEL 350SC COMPRESSOR UNIT



KEY

GAS FLOW

OIL FLOW

SELF-SEALING COUPLING

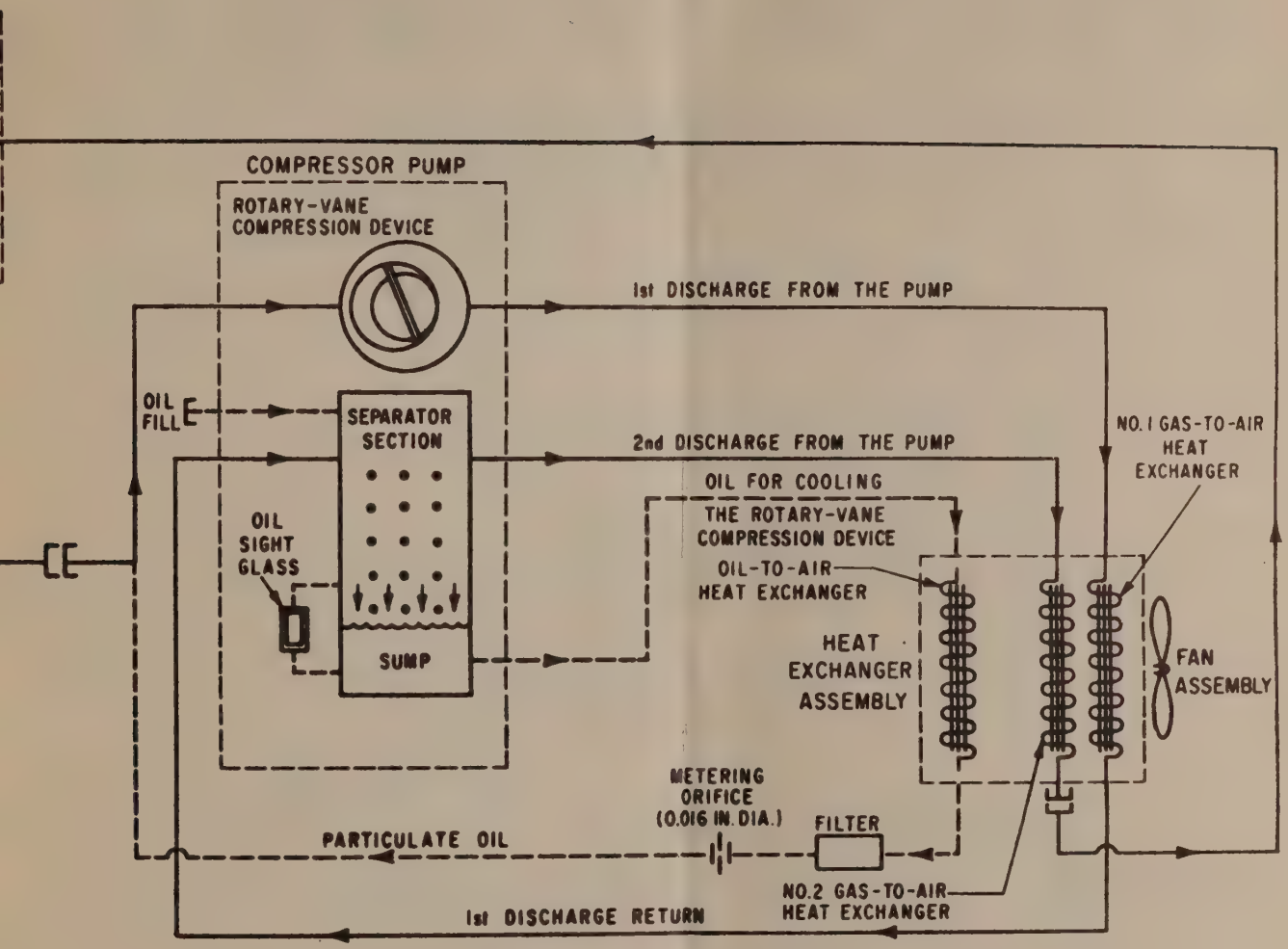


FIGURE 1-5. FLOW DIAGRAM FOR THE MODEL 350SC COMPRESSOR UNIT

CHAPTER 2
INSPECTION AND INSTALLATION

2.1 GENERAL

The components of the CRYO-TORR(R) 8 High-Vacuum Pump should already have been inspected for external evidence of damage incurred in shipping. If this has not been done, do so now. If evidence of damage is found, notify the shipper at once.

CAUTIONS: (1) WHEN CONNECTING OR DISCONNECTING A SELF-SEALING COUPLING, ALWAYS USE TWO WRENCHES (SUPPLIED) TO AVOID LOOSENING THE BODY OF THE COUPLING FROM ITS ADAPTER. FOR EXAMPLE, SEE FIGURES 2-3 AND 6-3.

(2) ALWAYS CHECK THAT THE FLAT RUBBER GASKET IS IN PLACE BEFORE CONNECTING A SELF-SEALING COUPLING.

(3) NEVER CONNECT OR DISCONNECT A SELF-SEALING COUPLING WHEN IT IS UNDER VACUUM. TO DO SO WILL CONTAMINATE THE ASSOCIATED COMPONENTS.

(4) DECONTAMINATE (IN ACCORDANCE WITH SECTION 6.4 OR 6.5) ANY COMPONENT THAT HAS LOST ITS HELIUM CHARGE, PRIOR TO CONNECTING THE COMPONENT INTO THE HIGH-VACUUM PUMP.

Note: For an understanding of the structure of a self-sealing coupling, see the cutaway views that are shown in Figure 6-2.

2.2 CRYOPUMP INSPECTION

Inspect these parts of the cryopump for evidence of damage:

(1) The exterior of the vacuum housing (17, Figure 1-2) and the cold head (19).

(2) The hydrogen-vapor-pressure gauge (14). This gauge should indicate 80 ± 2 psia.

(3) The louver assembly that comprises the 80K condensing array (1). Remove the protective cover (11) to inspect this assembly, which is located just inside the inlet of the vacuum housing.

(4) The mounting flange (13) and its O-ring groove.

CAUTION: REPLACE THE PROTECTIVE COVER UNLESS THE CRYOPUMP IS GOING TO BE INSTALLED IMMEDIATELY (SEE SECTION 2.4).

2.3 INTERCONNECTING-PIPING INSPECTION

Inspect the interconnecting piping for evidence of damage. In particular, look for kinks or broken strands in the outer braid.

The self-sealing couplings are shipped with dust caps and dust plugs in place. Do not remove these caps and plugs until the interconnecting piping is to be connected to the components of the high-vacuum pump (see Section 2.7).

> *CAUTION: DO NOT BEND THE FLEXIBLE INTERCONNECTING PIPING TO LESS THAN A SIX-INCH RADIUS OR DAMAGE MAY OCCUR. ALSO, AVOID TWISTING THE PIPING WHEN MAKING FINAL CONNECTIONS.*

2.4 CRYOPUMP INSTALLATION

The major interface dimensions of the CRYO-TORR(R) 8 Cryopump are shown in Figure 2-2. This cryopump may be installed in any orientation.

If possible, a high-vacuum isolation valve (commonly referred to as the Hi-Vac valve) should be installed between the cryopump and the User's vacuum chamber. This valve will isolate the cryopump from the User's vacuum chamber during preliminary vacuum pumping (rough-pumping), cooldown, and regeneration. It will also assist in troubleshooting. If no Hi-Vac valve is installed, the 15K inner charcoal chamber (3, Figure 1-2 and 5, Figure A-1 of Appendix A) may become heavily loaded during the cooldown process. This will result in lower pumping speeds for helium, hydrogen, and neon. Also, the cryopump will probably have to be regenerated more frequently.

It is recommended that the User install a high-vacuum gauge, capable of measuring vacuums to 10^{-8} torr or better, in the Hi-Vac valve in order to monitor the cryopump's performance when the Hi-Vac valve is closed.

The mounting flange on the vacuum housing is designed to mate with a 6-inch ANSI flanged connection. If some other mating connection is to be used, be sure that the inside diameter of that connection is at least 1/4 inch smaller than the inside diameter of the inlet O-ring groove (8 1/4-inch ID) on the cryopump. If the mating connection also has an O-ring groove, it will be necessary to interpose a double-sided, flat-faced ring at the interface.

> Note: As discussed in Section 1.2.1.1, an accessory port (29, Figure 1-2) is provided on the vacuum housing to enable a roughing valve and/or a vacuum gauge to be connected to the housing.

Install the cryopump as follows:

(1) Remove the protective cover (11, Figure 1-2).

(2) Remove and discard the inlet-seal O-ring (12) that was installed for shipment. Failure to replace the inlet-seal O-ring may be a potential source of vacuum leaks.

(3) Remove from its package the new inlet-seal O-ring that is supplied. Wipe the O-ring clean with a lint-free cloth or towel. Then sparingly lubricate it with low-vapor-pressure grease; for example, Apiezon "L" grease.

CAUTION: KEEP THE USE OF VACUUM-SYSTEM LUBRICANTS TO A MINIMUM TO AVOID CONTAMINATING THE VACUUM SYSTEM.

(4) Install the new inlet-seal O-ring.

(5) Bolt the cryopump to the User's flange. Tighten the mounting bolts evenly to ensure uniform compression of the O-ring and to prevent flange distortion. The final bolt torque should not exceed 20 ft-lb.

WARNING: THE RELIEF VALVE ASSEMBLY (18) ON THE VACUUM HOUSING (17) NORMALLY VENTS DIRECTLY TO THE ATMOSPHERE. IF THE CRYOPUMP IS TO BE USED WITH TOXIC, CORROSIVE, OR FLAMMABLE GASES, HOWEVER, CONNECT A VENT PIPE TO THE FLANGE ON THE RELIEF VALVE ASSEMBLY AND VENT THESE GASES TO A SAFE LOCATION. CARE MUST BE TAKEN IN MAKING THIS CONNECTION. A SUITABLE ADAPTER CAN BE FABRICATED BY USING VIEW B-B OF CTI-CRYOGENICS DRAWINGS E8033036 AND E8033047 (SEE APPENDIX G). THE 1.30-INCH-DIAMETER x 1.38-INCH-LONG VOLUME AROUND THE RELIEF VALVE MUST REMAIN CLEAR.

2.5 COMPRESSOR-UNIT INSPECTION (see Figure 1-4)

(1) Inspect the exterior of the compressor unit for shipping damage.

(2) Check the compressor-unit supply pressure gauge (7, Figure 1-4). It should indicate 260 ± 10 psig, or slightly higher if the compressor unit has been stored in a warm location.

Notes: (1) If the supply pressure gauge indicates zero pressure, assume that the compressor unit is contaminated. Pressurize the compressor unit in accordance with Section 6.3 and look for the leak. After repairing the leak, decontaminate the compressor unit in accordance with Section 6.4.2. Consult the Product Service Department of CTI-CRYOGENICS if there are any questions.

(2) Compressor units are shipped in an overcharged condition to allow for some loss of gas while connecting the unit. Instructions for adjusting the gas pressure to its proper value are given in Sections 2.7 and 6.3.

(3) Remove the rear grille (11).

(4) Using a flashlight, inspect the interior of the compressor unit for evidence of damage or oil loss.

(5) Check the oil level in the sight glass on the compressor pump. This level must be visible.

CAUTION: IF NO OIL IS VISIBLE, CONSULT THE PRODUCT SERVICE DEPARTMENT OF CTI-CRYOGENICS BEFORE PROCEEDING.

2.6 COMPRESSOR-UNIT PREPARATION AND INSTALLATION

Notes: (1) The compressor unit must be installed right-side-up on a surface that deviates from a level plane by no more than 10 degrees.

(2) The electrical-control panel and chassis located at the front of the compressor unit can be removed and mounted on a standard 19-inch rack. Such an installation will require modification of the cables from the electrical-control chassis to the compressor unit and the cryopump.

Proceed with the preparation and installation of the compressor unit as follows.

(1) Install the compressor unit so that the minimum clearance at the front and at the back is 12 inches (30 cm).

CAUTION: THIS MINIMUM CLEARANCE MUST BE PROVIDED IN ORDER TO ENSURE AN ADEQUATE FLOW OF AIR THROUGH THE COMPRESSOR UNIT. OTHERWISE, THE UNIT WILL OVERHEAT AND SHUT DOWN.

WARNING: ENSURE THAT BOTH OF THE SWITCHES ON THE FRONT OF THE COMPRESSOR UNIT ARE OFF BEFORE CONNECTING THE COMPRESSOR UNIT TO ITS POWER SOURCE.

(2) Plug the input power cable (4, Figure 1-4) into the power source. The power requirement for your compressor unit is given in Table 1-2.

(3) Turn the compressor unit on and leave it on for 15 minutes. (During this time, the gas will pass through the internal pressure-bypass valve). The purpose of this preliminary run is to return to the compressor-pump sump any oil that might have accumulated in the internal lines during shipment.

(4) Check that the fan is operating, and that air is drawn in through the fan and blows over the compressor pump before exhausting at the rear of the compressor unit.

(5) Check that the oil level is visible in the sight glass.

CAUTION: IF NO OIL IS VISIBLE, CONSULT THE PRODUCT SERVICE DEPARTMENT OF CTI-CRYOGENICS BEFORE PROCEEDING.

(6) Turn off the compressor unit and allow it to cool down, so that the adsorber can be connected.

WARNING: DISCONNECT THE COMPRESSOR UNIT FROM ITS POWER SOURCE BEFORE CONNECTING THE ADSORBER.

Note: The compressor unit is shipped from the factory with the adsorber installed but disconnected from the internal piping, in order to prevent any possibility of contaminating the charcoal in the adsorber with oil during shipment of the compressor unit. Failure to connect the adsorber will result in no helium flowing to the cold head and therefore no cryopumping.

(7) Remove the dust cap and the dust plug, respectively, from the self-sealing coupling half at the adsorber inlet and the mating self-sealing coupling half on the internal helium supply line. (This self-sealing coupling is located internally at the rear of the compressor unit; see Figure 2-3).

(8) Using the special wrenches supplied (see Appendix D), carefully connect the helium-supply-line coupling half to the adsorber-inlet coupling half (see Figure 2-3). Be sure the coupling is firmly seated but do not apply more than 35 foot-pounds of torque.

CAUTION: WHEN CONNECTING A SELF-SEALING COUPLING, ALWAYS USE TWO WRENCHES AND CHECK THAT THE FLAT RUBBER GASKET IS IN PLACE; SEE SECTION 2.1.

(9) Replace the rear grille on the compressor unit.

2.7 COMPONENT INTERCONNECTIONS

A component interconnection diagram for the CRYO-TORR(R) 8 High-Vacuum Pump is shown in Figure 2-1.

CAUTION: DO NOT CONNECT THE COMPRESSOR UNIT TO ITS POWER SOURCE UNTIL ALL INTERCONNECTIONS HAVE BEEN MADE AS FOLLOWS BETWEEN THE COMPONENTS OF THE HIGH-VACUUM PUMP. THIS WILL PRECLUDE THE POSSIBILITY OF HARMFUL ELECTRICAL DISCHARGES OCCURRING ACROSS EITHER ELECTRICAL CONNECTIONS OR PIPING CONNECTIONS WHILE THE COMPONENT INTERCONNECTIONS SHOWN IN FIGURE 2-1 ARE BEING MADE.

Note: The User's rough-pumping system that is depicted in Figure 2-1 is discussed in Section 3.2.

Proceed as follows with the component interconnections and related procedures.

(1) Remove the dust caps from the gas-supply and gas-return connectors on the cold head and on the rear of the compressor unit.

(2) Connect the interconnecting piping between the compressor unit and the cold head (see Figure 2-1) as specified below.

CAUTIONS: (1) IF A SELF-SEALING COUPLING STARTS TO LEAK, SCREW THE COUPLING HALVES TOGETHER FASTER.

(2) ALWAYS CONNECT THE PIPING TO THE COMPRESSOR UNIT FIRST AND THEN TO THE COLD HEAD. OTHERWISE, THERE IS DANGER OF INTRODUCING CONTAMINATION.

(a) Connect the helium return line to the gas-return connector (8, Figure 1-4) on the rear of the compressor unit.

(b) Connect the helium supply line to the gas-supply connector (9) on the rear of the compressor unit.

(c) Connect the helium supply line to the gas-supply connector (6, Figure 1-3) on the cold head.

(d) Connect the helium return line to the gas-return connector (5) on the cold head.

(3) Read the pressure on the compressor-unit supply pressure gauge. The desired static pressure is 250 +0, -5 psig at 75°F.

Note: Ensure that the compressor unit is in the ambient-temperature operating range (60°F to 100°F; 16°C to 38°C) before making this reading.

(4) If the indicated pressure is lower than 245 psig, add helium gas as described in Section 6.3.

Note: If the static pressure is below 240 psig, the performance of the cryopump may be less than shown in the specifications of Table 1-2.

(5) If the indicated pressure is higher than 250 psig, reduce the pressure as follows:

(a) Remove the flare cap from the gas charge fitting (6, Figure 1-4) on the rear of the compressor unit.

(b) While observing the supply pressure gauge, very slowly (and only slightly) open the gas charge valve and reduce the gauge indication to 250 psig.

(c) Close the gas charge valve after the correct charge pressure has been obtained, and reinstall the flare cap.

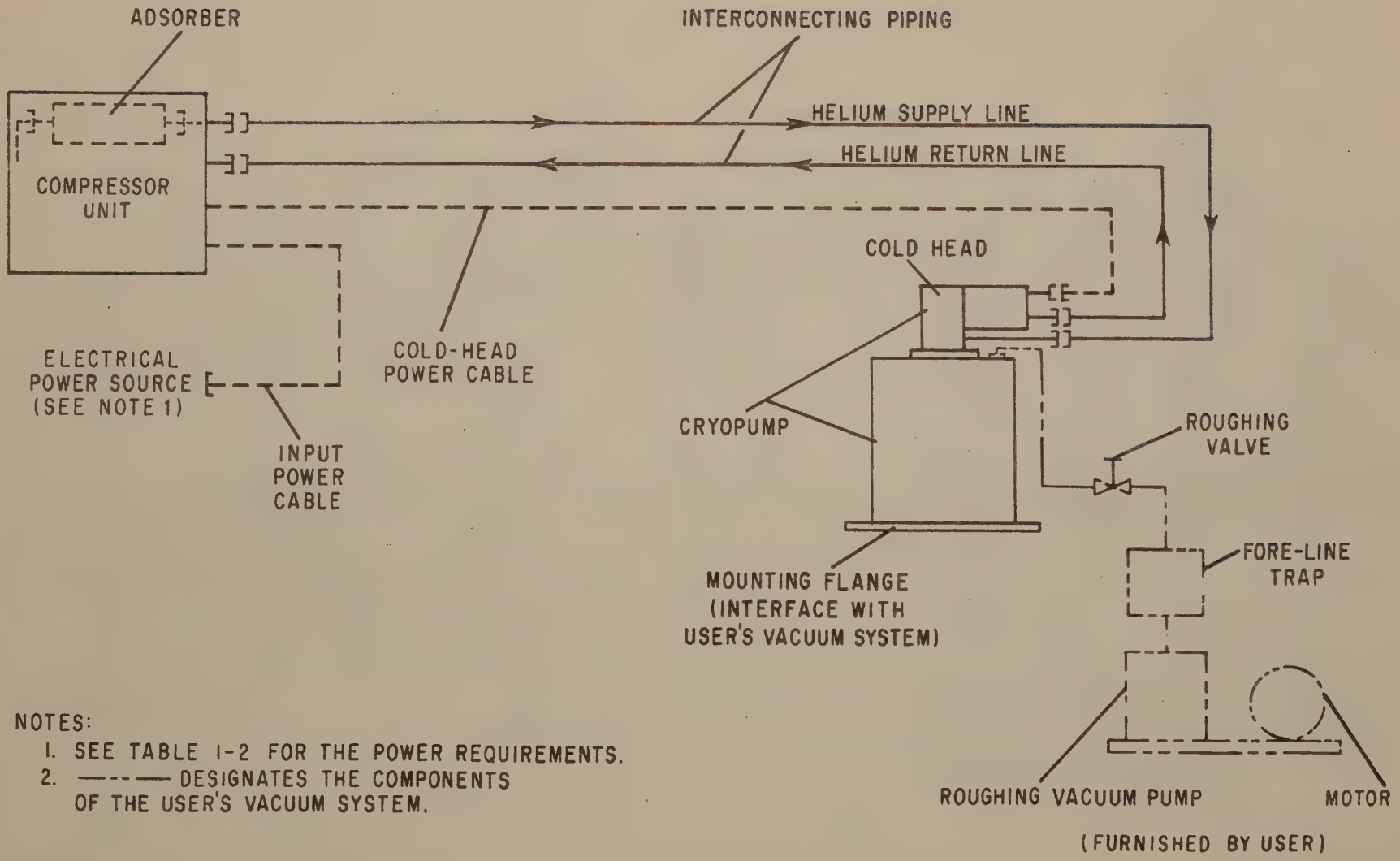
(6) Connect the cold-head power cable (5, Figure 1-4) of the compressor unit to the power connector (4, Figure 1-3) of the cold head.

CAUTION: NEVER CONNECT THE COLD-HEAD POWER CABLE TO THE COLD HEAD WHILE THE COMPRESSOR UNIT IS RUNNING. THIS WILL PRECLUDE THE POSSIBILITY OF HARMFUL ELECTRICAL DISCHARGES OCCURRING ACROSS THE ELECTRICAL CONNECTIONS.

(7) With the two "ON-OFF" switches of the compressor unit (1 and 2, Figure 1-4) switched off, plug the input power cable (4, Figure 1-4) into the power source. (See Table 1-2 for the applicable power requirements.)

WARNING: ENSURE THAT BOTH OF THE SWITCHES ON THE FRONT OF THE COMPRESSOR UNIT ARE OFF BEFORE CONNECTING THE COMPRESSOR UNIT TO ITS POWER SOURCE.

Note: Do not switch these two switches on until commencing the start-up and cooldown procedures; see Section 3.3.



NOTES:

1. SEE TABLE 1-2 FOR THE POWER REQUIREMENTS.
2. —·-·— DESIGNATES THE COMPONENTS OF THE USER'S VACUUM SYSTEM.

FIGURE 2-1. COMPONENT INTERCONNECTION DIAGRAM FOR THE CRYO-TORR® 8 HIGH-VACUUM PUMP

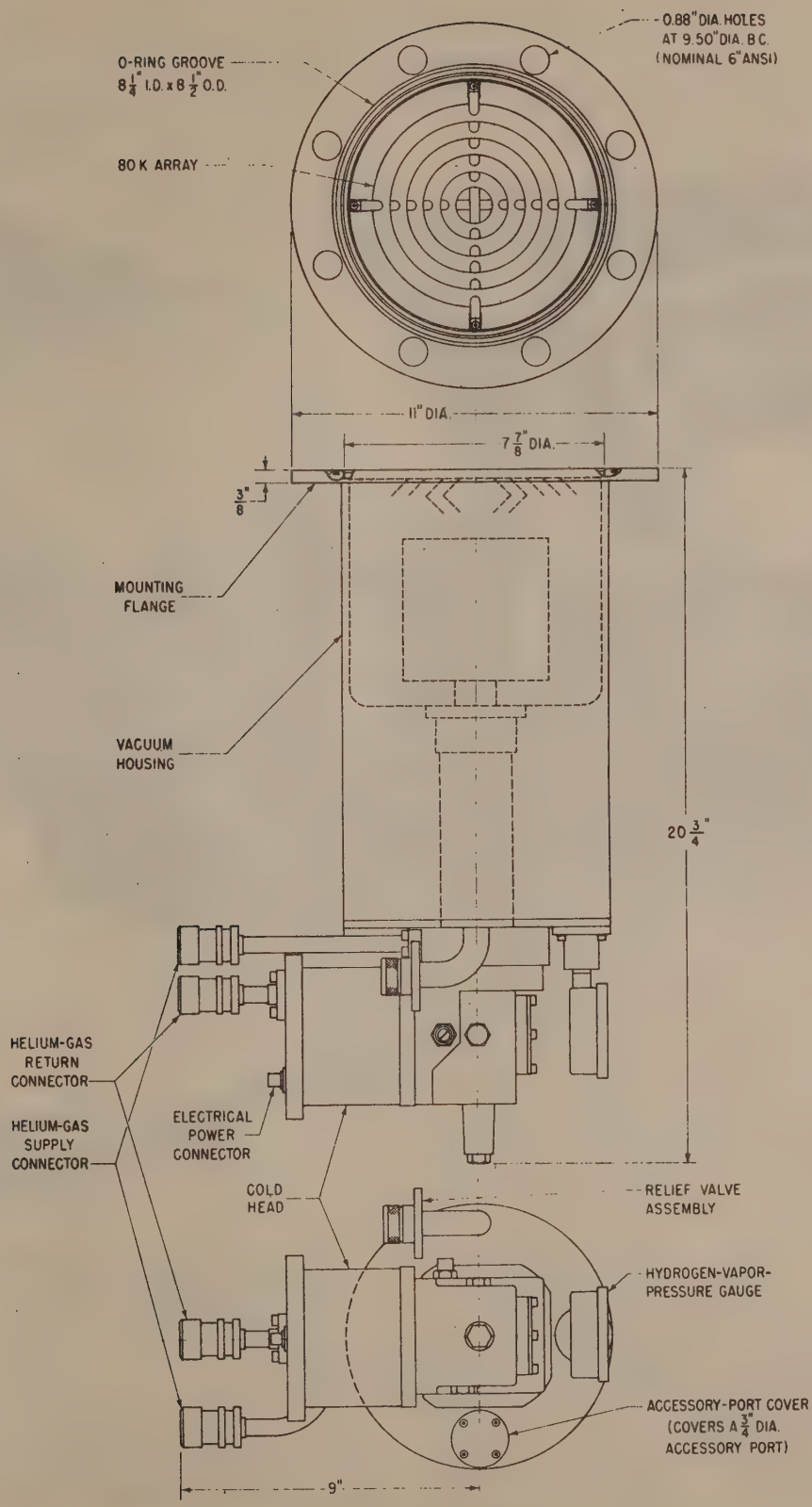
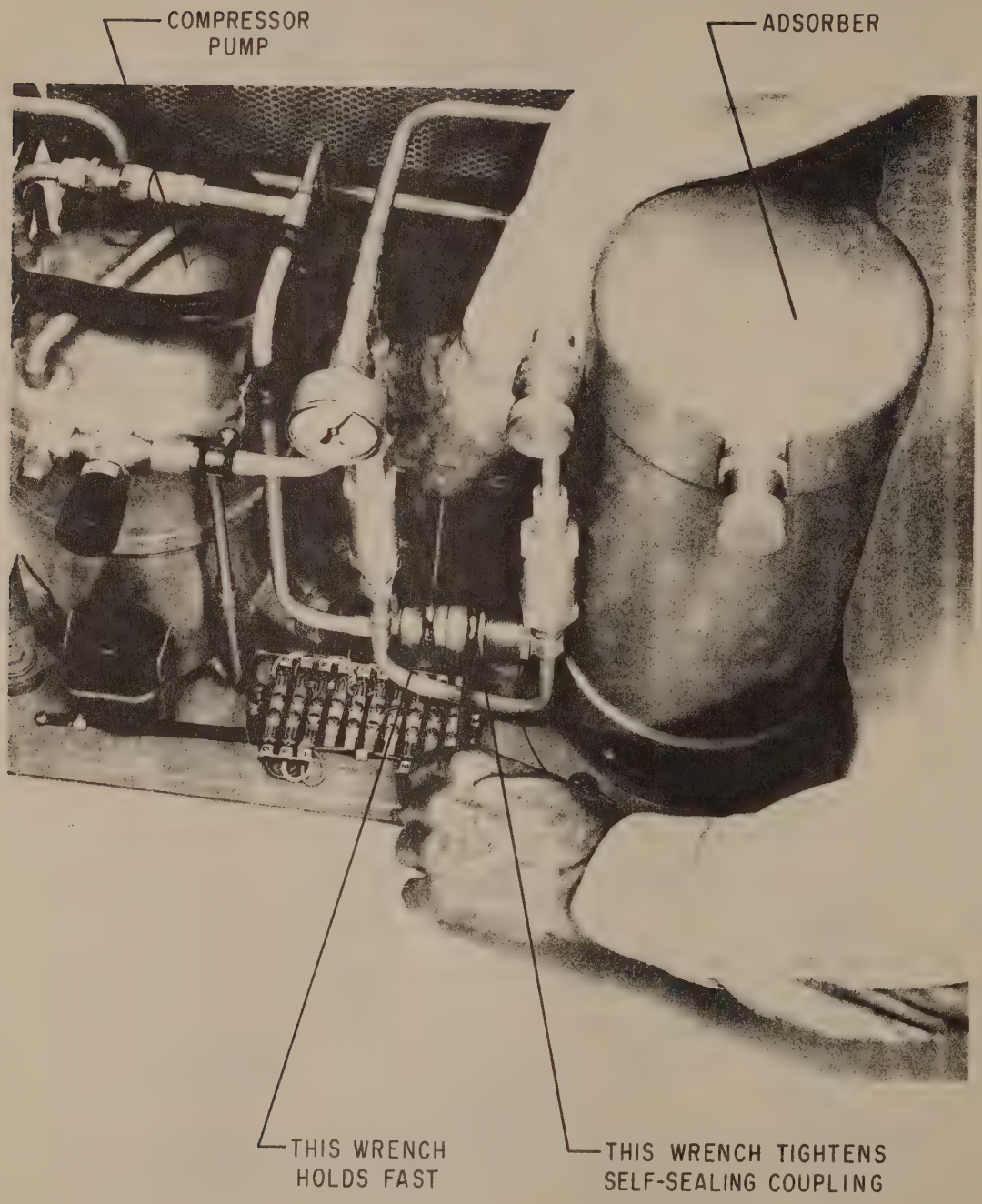


FIGURE 2-2. THE INSTALLATION INTERFACE OF THE CRYO-TORR® 8 CRYOPUMP



NOTE: THE COVER HAS BEEN REMOVED FOR THE SAKE OF CLARITY. ONLY THE REAR GRILLE HAS TO BE REMOVED IN ORDER TO CONNECT THE ADSORBER.

FIGURE 2-3. CONNECTING THE ADSORBER IN THE MODEL 350SC COMPRESSOR UNIT

CHAPTER 3
OPERATION

3.1 GENERAL

The following instructions assume that the CRYO-TORR(R) 8 High-Vacuum Pump has been properly interfaced with the User's vacuum system (see Section 2.4).

Prior to start-up ensure that:

(1) The component interconnections have been made (see Section 2.7).

(2) The adsorber has been connected into the compressor unit (see Section 2.6).

> Note: Failure to connect the adsorber will result in no helium flowing to the cold head and therefore no cryopumping.

(3) The various checks listed in Chapter 2 have been made.

(4) The cryopump is at room temperature and at atmospheric pressure.

(5) The supply pressure gauge on the rear of the compressor unit indicates a static pressure of 250 +0, -5 psig at 75°F.

(6) A vacuum gauge has been installed in the roughing line (see Figure 2-1) to monitor cryopump response during evacuation.

> Note: It is important to maintain an operating log, especially when operating the CRYO-TORR 8 High-Vacuum Pump for the first time or in a new installation. Readings of the hydrogen-vapor-pressure gauge and the compressor-unit supply pressure gauge should be recorded every 6 minutes during the initial cooldown. A set of these readings should be taken once a day while the high-vacuum pump is operating under normal load conditions. These records may be extremely useful later, both in recognizing degradation of performance and in troubleshooting.

3.2 PRELIMINARY VACUUM PUMPING (ROUGH-PUMPING)

> *CAUTION: DURING ROUGH-PUMPING, BACKSTREAMING OF MECHANICAL-PUMP OIL SHOULD BE MINIMIZED BY USING A MOLECULAR-SIEVE FORE-LINE TRAP (SEE FIGURE 2-1).*

(1) Ensure that the conditions noted in steps 1 through 6 of Section 3.1 have been met.

(2) Using a mechanical pump, rough-pump the cryopump to a pressure of 50 microns. When a new cryopump has been installed into the User's vacuum system, the initial evacuation may take longer than usual because of moisture in the 15K inner charcoal chamber.

CAUTION: DO NOT ROUGH-PUMP THE CRYOPUMP ANY LONGER THAN IS NECESSARY TO SATISFY STEPS 3 AND 4 BELOW.

Note: If no Hi-Vac valve (see Section 2.4) is installed between the cryopump and the User's vacuum chamber, it may be impossible to attain the desired 50-micron vacuum. In this case, the vacuum in the User's vacuum chamber should be reduced to as low a level as possible.

(3) Close the roughing valve and note the rate at which pressure rises in the cryopump. If the rate is 10 microns/minute or less, start the cryopump.

(4) If the rate is greater than 10 microns/minute, repeat steps 1 and 2.

Note: If the pump-down takes a long time, refer to the cryopump troubleshooting procedures provided in Table 5-1.

3.3 START-UP AND COOLDOWN

(1) Rough-pump the cryopump in accordance with Section 3.2.

CAUTION: NEVER LEAVE THE ROUGHING VALVE OPEN WHEN THE CRYOPUMP IS OPERATING. OIL FROM THE MECHANICAL PUMP COULD BACKSTREAM AND CONTAMINATE THE CHARCOAL IN THE CRYOPUMP.

(2) Record in the operating log the readings of the hydrogen-vapor-pressure gauge, the compressor-unit supply pressure gauge, and the elapsed-time meter.

(3) Switch on the compressor-unit "ON-OFF" switch (1, Figure 1-4).

(4) Switch on the cold-head "ON-OFF" switch (2).

(5) Record the compressor-unit supply pressure, the hydrogen vapor pressure, and, if possible, the vacuum reading of the cryopump every 6 minutes during the initial cooldown.

(6) With the Hi-Vac valve closed, the cryopump should achieve a second-stage-cold-station temperature of 20K or less (15 psia or less on the hydrogen-vapor-pressure gauge) in approximately 90 minutes. (If the Hi-Vac valve is open to the User's vacuum chamber, a cooldown to this temperature range will take longer.)

Note: If the cryopump is not cryogenically cold (as indicated by a reading of the hydrogen-vapor-pressure gauge that is 46 psia or less) or has not achieved an insulating vacuum of 10^{-3} torr or better by 2-1/2 hours, refer to the cryopump troubleshooting procedures provided in Table 5-1.

(7) Rough-pump the User's vacuum chamber to a suitable crossover pressure (see Section 1.4).

(8) Close the roughing valve.

(9) Open the Hi-Vac valve.

Table 3-1 indicates typical ranges of pressure variations (including hydrogen-vapor-pressure readings) with time during cooldowns. The values listed are dependent upon the heat load of the cold head. Pressure regulation during cooldown is automatic (see Section 1.2.2.2).

TABLE 3-1. TYPICAL PRESSURE VARIATIONS DURING COOLDOWNS AND DURING NORMAL OPERATION

Time	Helium Supply Pressure (psig)	Helium Return Pressure* (psig)	Hydrogen Vapor Pressure (psia)
Prior to start-up	250	250	80
10 mins. after start-up	270-290	85-105	80
45 mins. after start-up	270-290	90-110	75
1 hour after start-up	270-290	95-115	70
2 hours after start-up	270-290	110-130	Less than 15
During Normal Operation	270-290	110-130	0-10

Note: The ultimate vacuum level of the cryopump is in the middle of the 10^{-8} torr range. This level is not affected by the cold-head temperature unless the reading of the hydrogen-vapor-pressure gauge is above 12 psia. Should this condition exist, check the entire system to determine the cause.

*A gauge is not supplied to read the helium return pressure but one can be installed in the return line by using an optional "charging tee".

3.4 NORMAL OPERATION

The components of the CRYO-TORR(R) 8 High-Vacuum Pump are designed to operate unattended under normal conditions. The values given in Table 3-1 for normal operating conditions are indicators of normal performance. If there is a substantial variation from these values, it is likely that the User's vacuum system, the cryopump, or the compressor unit is malfunctioning.

During normal operation, the operating log should be filled out at least once a day.

During the first 100 hours of operation, a slight drop in the oil level of the compressor pump may occur. Such a drop should cause no concern, as long as the oil level is visible. However, if the oil level continues to drop, to the extent that it is no longer visible, contact the Product Service Department of CTI-CRYOGENICS.

3.5 SHUTDOWN

(1) Close the Hi-Vac valve between the cryopump and the User's vacuum chamber.

(2) Switch OFF the cold-head "ON-OFF" switch (2, Figure 1-4).

(3) Switch OFF the compressor-unit "ON-OFF" switch (1).

CAUTIONS: (1) IF IT IS NECESSARY TO EXPOSE THE USER'S VACUUM CHAMBER TO ATMOSPHERIC PRESSURE, EITHER SHUT THE HI-VAC VALVE TO ISOLATE THE CRYOPUMP FROM THE USER'S VACUUM CHAMBER OR BACKFILL THE CRYOPUMP THROUGH THE ACCESSORY PORT (29, FIGURE 1-2) WITH DRY GAS, SUCH AS NITROGEN OR ARGON.

(2) DO NOT EXPOSE THE COLD INTERNAL PARTS OF THE CRYOPUMP TO THE ATMOSPHERE AFTER IT HAS BEEN SHUT DOWN. ALWAYS ALLOW TIME FOR THEM TO WARM UP TO ROOM TEMPERATURE BEFORE EXPOSURE. THIS IS TO MINIMIZE THE AMOUNT OF WATER VAPOR THAT IS ADSORBED INTO THE CHARCOAL OF THE 15K INNER CHARCOAL CHAMBER (3, FIGURE 1-2).

Note: It will take several hours to warm up the cold-head cylinder to ambient temperature with no heat load present. If a rapid warm-up is desired, break the vacuum in the User's vacuum chamber with a small amount of clean, dry gas, such as nitrogen or argon. Do not use helium to break the vacuum because of the difficulty in removing it later.

3.6 STORAGE

During storage of the CRYO-TORR(R) 8 High-Vacuum Pump while the cryopump is attached to the User's vacuum system, the vacuum housing should either be (a) maintained under vacuum or (b) kept at atmospheric pressure with dry nitrogen or argon.

The remainder of the CRYO-TORR 8 High-Vacuum Pump will be fully protected in storage if it is kept under positive helium pressure. Best results will be obtained if all components are left completely connected. The helium-supply pressure gauge on the rear panel of the compressor unit should be checked periodically to ensure that a charge pressure of 250 +0, -5 psig is being maintained.

If the cryopump is removed from the User's vacuum system, install the protective cover (11, Figure 1-2) on the mounting flange (13) at the inlet of the vacuum housing (17). Then evacuate the cryopump through the accessory port (29) and/or backfill it with a dry gas, such as nitrogen or argon.

CHAPTER 4
REGENERATION

4.1 GENERAL

All cryopumps operate by the condensation and adsorption of gases upon cold surfaces. Frost then forms upon these cold surfaces. Eventually, it becomes so thick that the cryopump must be regenerated. That is, the cold internal parts of the cryopump must be warmed to room temperature and the re-evolved gases removed.

The need for regeneration is evident when the cryopump is incapable of maintaining a high vacuum even though the cold head and the compressor unit are operating satisfactorily. Typically, an increase in the blank-off pressure of more than two decades may be taken as an indication that the cryopump needs regeneration. (The blank-off pressure of a cryopump is the lowest pressure that can be maintained in the vacuum housing of the cryopump when the Hi-Vac valve is closed; see Section 2.4.)

The need for regeneration may also be revealed by a hydrogen-vapor-pressure-gauge reading above 15 psia or, when the cryopump is equipped with the optional silicon-diode temperature sensor, by an indicated temperature that is greater than 20K. Such a high reading may be caused by a number of conditions, including (1) overloading of the cryopump by an excessive gas burst from the User's vacuum chamber at crossover, (2) the presence of a high partial pressure of noncondensibles (helium, hydrogen, and neon) within the cryopump, due to exceeding the adsorptive capacity of the charcoal in the 15K inner charcoal chamber of the cryopump, and (3) an excessive thermal load due to build-up of H_2O ice on the 80K condensing array.

Some Users prefer to perform regeneration at routine intervals, rather than waiting for obvious need to become evident. A suitable time interval must be determined by experience. It will depend upon the gas load that is being pumped and the pressure in the User's vacuum chamber.

WARNING: IF TOXIC, CORROSIVE, OR FLAMMABLE GASES ARE BEING PUMPED, CONNECT A VENT PIPE TO THE FLANGE ON THE RELIEF VALVE ASSEMBLY (18, FIGURE 1-2) AND VENT THESE GASES TO A SAFE LOCATION.

CAUTION: CARE MUST BE TAKEN IN MAKING THIS CONNECTION. A SUITABLE ADAPTER CAN BE FABRICATED BY USING VIEW B-B OF CTI-CRYOGENICS DRAWINGS E8033036 AND E8033047 (SEE APPENDIX G). THE 1.30-INCH-DIAMETER X 1.38-INCH-LONG VOLUME AROUND THE RELIEF VALVE MUST REMAIN CLEAR.

Note: CTI-CRYOGENICS Regeneration Control Unit (CTI-CRYOGENICS part number E8044001) can be used to automatically sequence the events in the various regeneration procedures.

4.2 UNASSISTED REGENERATION

(1) Shut down the CRYO-TORR(R) 8 High-Vacuum Pump in accordance with Section 3.5.

(2) Allow the cryopump arrays to warm up to ambient temperature; that is, until the hydrogen-vapor-pressure gauge indicates 80 psia or, if the cryopump is equipped with the optional silicon-diode temperature sensor, until the indicated temperature is greater than 290K. (The required warm-up time is from two to six hours.)

> *CAUTION: DO NOT ROUGH-PUMP THE CRYOPUMP UNTIL IT HAS WARMED UP TO AMBIENT TEMPERATURE. IT IS DIFFICULT TO REMOVE WATER FROM CHARCOAL AT LOWER-THAN-AMBIENT TEMPERATURES. (WHEN THE CRYOPUMP IS EQUIPPED WITH THE OPTIONAL SILICON-DIODE TEMPERATURE SENSOR, DO NOT ROUGH-PUMP THE CRYOPUMP IF THE INDICATED TEMPERATURE IS LESS THAN 290K.)*

(3) After the cryopump arrays are at ambient temperature, rough-pump the cryopump down to 50 millitorr, using the procedure of Section 3.2.

(4) Restart the high-vacuum pump in accordance with Section 3.3.

4.3 RAPID REGENERATION

The unassisted-regeneration process described in Section 4.2 can be accelerated by forced warming of the cryopump. Such rapid regeneration may be accomplished by any one of the five following procedures.

> *CAUTION: DO NOT HEAT THE CRYOPUMP ABOVE 150°F (66°C) WHEN USING THESE PROCEDURES. TO DO SO WILL RESULT IN DAMAGE TO SOME MATERIALS IN THE CRYOPUMP.*

Procedure No. 1: Backfilling the cryopump with a dry gas

> Note: The use of this backfilling procedure will shorten by 10 to 20 percent the regeneration time that is required with the unassisted-regeneration procedure of Section 4.2.

(a) Close the Hi-Vac valve if the User's vacuum system is so equipped.

(b) Shut down the CRYO-TORR(R) 8 High-Vacuum Pump in accordance with Section 3.5.

(c) Break the vacuum in the cryopump vacuum chamber with dry nitrogen or argon gas, applied through the accessory port (29, Figure 1-2).

> *CAUTION: NEVER USE HELIUM GAS TO BREAK THE VACUUM. HELIUM IS THE MOST DIFFICULT GAS TO CRYOPUMP AND EXCESSIVE QUANTITIES OF HELIUM REMAINING IN THE CRYOPUMP AFTER REGENERATION MAY IMPEDE OR LIMIT THE USEFUL OPERATION OF THE CRYOPUMP. EXCESSIVE QUANTITIES OF HELIUM WILL ALSO SHORTEN THE TIME BETWEEN SUBSEQUENT REGENERATIONS.*

(d) Allow the crypoump arrays to warm up to ambient temperature; that is, until the hydrogen-vapor-pressure gauge indicates 80 psia or, if the cryopump is equipped with the optional silicon-diode temperature sensor, until the indicated temperature is greater than 290K.

CAUTION: DO NOT ROUGH-PUMP THE CRYOPUMP UNTIL IT HAS WARMED UP TO AMBIENT TEMPERATURE. IT IS DIFFICULT TO REMOVE WATER FROM CHARCOAL AT LOWER-THAN-AMBIENT TEMPERATURES. (WHEN THE CRYOPUMP IS EQUIPPED WITH THE OPTIONAL SILICON-DIODE TEMPERATURE SENSOR, DO NOT ROUGH-PUMP THE CRYOPUMP IF THE INDICATED TEMPERATURE IS LESS THAN 290K.)

(e) Rough-pump the cryopump in accordance with Section 3.2.

(f) Restart the high-vacuum pump in accordance with Section 3.3.

Procedure No. 2: Room-temperature purging of the cryopump

Note: The use of this room-temperature purging procedure will shorten by 20 to 30 percent the regeneration time that is required with the unassisted-regeneration procedure of Section 4.2.

(a) Close the Hi-Vac valve if the User's vacuum system is so equipped.

(b) Shut down the CRYO-TORR(R) 8 High-Vacuum Pump in accordance with Section 3.5.

(c) Start a dry-gas purge (using nitrogen or argon) of the cryopump through the accessory port (29, Figure 1-2) with a flow rate of 1 to 2 cfm.

(d) Continue the purging until the hydrogen-vapor-pressure gauge indicates 80 psia or, if the cryopump is equipped with the optional silicon-diode temperature sensor, until the indicated temperature is greater than 290K.

(e) Rough-pump the cryopump in accordance with Section 3.2.

(f) Restart the high-vacuum pump in accordance with Section 3.3.

Procedure No. 3: Hot-gas purging of the cryopump

WARNING: DO NOT USE AN OPEN HOT-FILAMENT HEATER THAT IS EXPOSED TO THE PURGE-GAS STREAM. IT COULD BE A SOURCE OF IGNITION FOR FLAMMABLE GASES.

Note: The use of the following hot-gas purging procedure will accelerate the regeneration process obtained with Procedure No. 2.

(a) Close the Hi-Vac valve if the User's vacuum system is so equipped.

(b) Shut down the CRYO-TORR(R) 8 High-Vacuum Pump in accordance with Section 3.5.

(c) Start a dry-gas purge (using nitrogen or argon that has been preheated to no more than 150°F (66°C)) of the cryopump through the accessory port (29, Figure 1-2) with a flow rate of 1 to 2 cfm.

CAUTION: DO NOT HEAT THE CRYOPUMP ABOVE 150°F (66°C).

(d) Continue the purging until the hydrogen-vapor-pressure gauge indicates 80 psia or, if the cryopump is equipped with the optional silicon-diode temperature sensor, until the indicated temperature is greater than 290K.

(e) Rough-pump the cryopump in accordance with Section 3.2.

(f) Restart the high-vacuum pump in accordance with Section 3.3.

Procedure No. 4: Heating the cryopump

(a) Close the Hi-Vac valve if the User's vacuum system is so equipped.

(b) Shut down the CRYO-TORR(R) 8 High-Vacuum Pump in accordance with Section 3.5 and break the vacuum within the cryopump with a suitable dry gas (see step c of Procedure No. 1).

(c) Wrap the exterior of the vacuum housing (17, Figure 1-2) with a heating mantle or heating tape, and maintain the surface of the cryopump at a temperature up to 150°F (66°C).

CAUTION: DO NOT HEAT THE CRYOPUMP ABOVE 150°F (66°C).

(d) Allow the cryopump arrays to warm up to ambient temperature; that is, until the hydrogen-vapor-pressure gauge indicates 80 psia or, if the cryopump is equipped with the optional silicon-diode temperature sensor, until the indicated temperature is greater than 290K.

(e) Rough-pump the cryopump in accordance with Section 3.2.

(f) Restart the high-vacuum pump in accordance with Section 3.3.

Procedure No. 5: Using both heating and purging

WARNING: DO NOT USE AN OPEN HOT-FILAMENT HEATER THAT IS EXPOSED TO THE PURGE-GAS STREAM. IT COULD BE A SOURCE OF IGNITION FOR FLAMMABLE GASES.

(a) Close the Hi-Vac valve if the User's vacuum system is so equipped.

(b) Shut down the CRYO-TORR(R) 8 High-Vacuum Pump in accordance with Section 3.5.

(c) Wrap the exterior of the vacuum housing (17, Figure 1-2) with a heating mantle or heating tape, and maintain the surface temperature of the cryopump at a temperature up to 150°F (66°C).

CAUTION: DO NOT HEAT THE CRYOPUMP ABOVE 150°F (66°C).

(d) Start a dry-gas purge (using nitrogen or argon) of the cryopump through the accessory port (29, Figure 1-2) with a flow rate of 1 to 2 cfm.

(e) Continue the heating and purging until the hydrogen-vapor-pressure gauge indicates 80 psia or, if the cryopump is equipped with the optional silicon-diode temperature sensor, until the indicated temperature is greater than 290K.

(f) Rough-pump the cryopump in accordance with Section 3.2.

(g) Restart the high-vacuum pump in accordance with Section 3.3.

CHAPTER 5

TROUBLESHOOTING

5.1 TROUBLESHOOTING THE CRYOPUMP

The primary indication of trouble in a vacuum pumping system is a rise in the pressure of the User's vacuum chamber (called the base pressure). A rise in the base pressure may be caused by either a leak in the User's vacuum system or an improperly functioning cryopump. If the base pressure becomes high enough to indicate trouble, first determine if there is a leak in the User's vacuum system. If there is none, the trouble is with the cryopump.

A log of the readings of the hydrogen-vapor-pressure gauge during normal operation is a valuable tool in troubleshooting the cryopump. Values higher than 15 psia indicate that the second-stage cold station is warmer than 20K, and that the cryopump's ability to pump hydrogen is therefore impaired.

The cryopump troubleshooting procedures are summarized in Table 5-1.

5.2 TROUBLESHOOTING THE COMPRESSOR UNIT

The compressor-unit troubleshooting procedures are summarized in Table 5-2.

TABLE 5-1. CRYOPUMP TROUBLESHOOTING CHART

FAULT	POSSIBLE CAUSE	CORRECTIVE ACTION
#1 High base pressure, with hydrogen vapor pressure more than 15 psia.	1) The hydrogen capacity of the inner charcoal chamber has been exceeded.	Regenerate the cryopump to expel the condensed gases. Recool the cryopump and check its operation. Compare the cooldown parameters (cooldown time to operating temperature and the time required to achieve the desired operating vacuum of the cryopump; see Section 3.3) with those obtained previously (see operating log). If these are not essentially similar, the cold head is probably at fault.
	2) Gas conduction in the system has exceeded the gas-condensing capacity of the 15K array, and frost build-up has caused the equilibrium vacuum pressure to be higher than 1×10^{-4} torr.	
	3) The cryopump has been overloaded by an excessive gas burst at crossover.	
	4) Cold-head performance has degraded because of mechanical failure.	Check the supply pressure gauge on the compressor unit. The normal operating supply pressure should be 270-290 psig. If the reading is below this range, add gas (see Section 6.3). Regenerate and recool the cryopump. If the hydrogen vapor pressure remains high, the trouble may lie within the cold head itself. Also, check the compressor unit for normal operation (see Section 3.6).

TABLE 5-1. CRYOPUMP TROUBLESHOOTING CHART (cont.)

FAULT	POSSIBLE CAUSE	CORRECTIVE ACTION
#2 High base pressure, with hydrogen vapor pressure 15 psia or lower.	1) Frost build-up. The condensation capacity of the cryopump has been exceeded. The temperature gradient through the condensed layer has caused the base pressure to rise to the level of the vapor pressure of the condensed gas.	Regenerate the cryopump as described in Chapter 4.
	2) Either the 15K array or the 80K array has become loose and does not make good thermal contact with its cold station on the cold head. This is an unlikely situation and should be the last suspected cause of poor vacuum performance.	Warm the cryopump to ambient temperature, and remove it from the User's vacuum system. Inspect the arrays and retighten them as necessary.
#3 The cryopump fails to cool down to the required operating temperature, or takes too long to reach that temperature.	1) Low system charge pressure in the compressor unit.	Add gas in accordance with Section 6.3.
	2) The cryopump has an excessive heat load.	Eliminate the cause of the excessive heat load and regenerate the cryopump.
	3) The cryopump is contaminated.	Purge and regenerate the cryopump, as outlined in Section 4.3.
	4) Internal compressor-unit problem.	See Table 5-2.

TABLE 5-2. COMPRESSOR-UNIT TROUBLESHOOTING CHART

WARNING: DISCONNECT THE POWER BEFORE MAKING ANY CONTINUITY CHECKS.

FAULT	POSSIBLE CAUSE	CORRECTIVE ACTION
#1 The compressor unit fails to start when power is applied.	1) No power at the User's power source.	Check the service fuses, circuit breakers, and wiring associated with the User's power source and fix as required.
	2) Incorrect or disconnected wiring within the compressor unit.	Check the compressor-unit wiring (see Figure B-1 in Appendix B).
	3) The overload protective switch (TS2) is open. (In this case, the cooling fan will run but the compressor pump will not.)	If the contact points of this switch are open when excess current is not being drawn, the switch is defective. Use the schematic of Figure B-1 and an ohmmeter to check whether the switch is open or closed. (When switch TS2 opens because of excessive current draw, the cause must be ascertained; see Possible Cause 1 for Fault No. 2.)
	4) The thermal protective switch (TS1) or the safety interlock switch (SW2) is closed.	Allow the compressor unit to cool, and then remove the compressor-unit cover. Test switches TS1 and SW2 as follows. Depress the plunger on the interlock switch (located on the side of the heat exchanger). Both switches should now be open. Test either switch for continuity. If continuity is found, contact the Product Service Department of CTI-CRYOGENICS for assistance. (Note that switches TS1 and SW2 are schematically equivalent and cannot be tested separately without altering the wiring in the electrical-control chassis.)

TABLE 5-2. COMPRESSOR-UNIT TROUBLESHOOTING CHART (cont.)

FAULT	POSSIBLE CAUSE	CORRECTIVE ACTION
#2 The compressor pump stops after several minutes of operation.	1) Excessive current draw has caused the overload protective switch (TS2) to open. (In this case, the cooling fan will run even though the compressor pump can not.)	Allow the compressor unit to cool. The compressor pump should start automatically when it has cooled sufficiently. If it does so, and stops again after several minutes of operation, contact the Product Service Department of CTI-CRYOGENICS for assistance.
	2) The voltage from the User's power source is too low.	Measure the voltage being supplied to the compressor unit. If it is low (see specifications in Table 1-2), the problem is not in the compressor unit.
	3) High temperature has caused the thermal protective switch (TS1) to close.	Check the oil level in the compressor pump. The oil level should be visible in the sight glass.
	4) The ambient temperature is unusually high.	Ensure that a free flow of air is provided to the compressor unit. Check that there is a minimum clearance of 12 inches (30 cm) at the front and back of the compressor unit. Also, check that the heat-exchanger surfaces are unobstructed and clean.
	5) Mechanical seizure.	Contact the Product Service Department of CTI-CRYOGENICS to discuss the repair or disposition of the unit.

CHAPTER 6

SERVICING AND MAINTENANCE

6.1 GENERAL

The CRYO-TORR(R) 8 High-Vacuum Pump requires little maintenance. The only scheduled service procedure is the replacement of the adsorber after every 10,000 hours of operation. Unscheduled maintenance is concerned primarily with the addition of helium gas to the system, as needed.

> *WARNING: IT IS ADVISABLE TO DISCONNECT THE COMPRESSOR UNIT FROM THE SOURCE OF ELECTRICAL POWER AS WELL AS FROM THE INTERCONNECTING PIPING TO THE COLD HEAD BEFORE PERFORMING ANY INTERNAL SERVICING OPERATIONS ON THE COMPRESSOR UNIT.*

6.2 REPLACING THE ADSORBER

Replace the adsorber as follows after a maximum of 10,000 hours of operation, as indicated by the elapsed-time meter on the front panel of the compressor unit.

> *CAUTION: ALWAYS USE TWO WRENCHES WHEN DISCONNECTING OR CONNECTING A SELF-SEALING COUPLING. SEE SECTION 2.1.*

(1) Shut down the CRYO-TORR 8 High-Vacuum Pump in accordance with Section 3.5.

(2) Disconnect the input power cable (4, Figure 1-4) of the compressor unit from the electrical power source.

(3) Disconnect the helium return and supply lines from the connectors (8, 9) at the rear of the compressor unit.

(4) Remove the rear grille (10), the front grille (11), and the cover (12) by removing the 22 screws that secure these items to the compressor unit. There is no need to remove the front panel (13) or the rear panel (14), just the 4 screws that pass through each panel and screw into the cover.

(5) Remove the bolts, nuts, and washers that secure the adsorber to the base of the compressor unit (see step 1, Figure 6-1).

> Note: Retain these items for use in securing the replacement adsorber to the base of the compressor unit.

(6) Disconnect the self-sealing coupling between the internal helium supply line and the adsorber inlet (see step 2, Figure 6-1 and Figure 6-3).

(7) Remove the jam nut and lock washer that secure the adsorber-outlet self-sealing coupling half to its support plate (see step 3, Figure 6-1).

Note: Retain these items for use in securing the replacement adsorber to the support plate.

(8) Carefully slide the adsorber inward until the adsorber-outlet self-sealing coupling half clears the support plate, and then remove the adsorber (see step 3, Figure 6-1).

WARNING: DEPRESSURIZE THE ADSORBER BEFORE DISPOSING OF IT. TO ACCOMPLISH THIS, ATTACH A MATING SELF-SEALING COUPLING HALF TO THE COUPLING HALF AT THE ADSORBER OUTLET AND TIGHTEN IT SLOWLY.

(9) Install the replacement adsorber as follows.

(a) Remove the dust caps from the self-sealing coupling halves at the adsorber inlet and the adsorber outlet.

(b) Carefully lower the adsorber into its correct position in the compressor unit, so that (see Figure 6-1) the self-sealing coupling half at the adsorber outlet fits into the support plate and the slots at the bottom of the adsorber are positioned over the holes in the base of the compressor unit.

(c) Secure the adsorber to the base of the compressor unit with the bolts, nuts, and washers that were removed in step 5.

(d) Secure the adsorber-outlet self-sealing coupling half to its support plate with the jam nut and washer that were removed in step 7.

(e) Carefully connect the self-sealing coupling half at the adsorber inlet to the mating self-sealing coupling half on the internal helium supply line (see Figure 2-3).

CAUTION: WHEN CONNECTING A SELF-SEALING COUPLING, ALWAYS USE TWO WRENCHES AND CHECK THAT THE FLAT RUBBER GASKET IS IN PLACE; SEE SECTION 2.1.

(10) Replace the cover and the front and rear grilles and secure them with their screws.

Note: In some compressor units, there is a metal tab inside the cover that must depress a white safety interlock switch when the cover is installed. In such compressor units, it is very easy to install the cover backwards, with the result that the safety interlock switch does not become depressed and the compressor unit can not be started.

(11) Check that the supply pressure gauge is at 250 psig. If additional gas pressure is required, follow the instructions given in Section 6.3.

(12) Add 10,000 hours to the reading on the elapsed-time meter, and write this total on the decal provided with the replacement adsorber. Affix this decal to the front panel of the compressor unit, next to the elapsed-time meter.

(13) Reconnect the helium return and supply lines to the connectors (8 and 9, Figure 1-4) at the rear of the compressor unit.

(14) Reconnect the input power cable to the electrical power source.

6.3 ADDING HELIUM GAS

During normal operation, it should rarely be necessary to add gas. If the need to add gas arises frequently, it is important to check for leakage since repeated addition of gas to maintain pressure can introduce contaminants if improper methods are used; this can eventually cause the cold head to fail. Many leaks are caused by improperly tightened self-sealing coupling connections or improperly seated relief valves. If there is a leak, fix it or replace the leaking component.

To add gas, proceed as follows.

CAUTION: DO NOT USE HELIUM GAS THAT IS LESS THAN 99.995% PURE.

(1) Remove the flare cap from the helium-gas charge fitting (6, Figure 1-4) on the rear of the compressor unit.

(2) Connect a helium bottle to the gas charge fitting by loosely attaching a charging line from the helium pressure regulator on the bottle to the 1/4-inch male flare fitting installed on the helium charge valve.

Notes: (1) The use of a two-stage regulator having a delivery pressure in the range from 10 to 300 psig is recommended.

(2) After the regulator has been installed on the helium bottle but before the bottle valve has been opened, it is important that the adjusting screw on the regulator be turned clockwise until the regulator is open. Then open the valve on the bottle and immediately back off on the regulator adjusting screw until the helium stops flowing. This procedure is required in order that both the regulator and the charging line will be purged and the air trapped in the regulator will not diffuse into the bottle.

(3) Set the pressure regulator on the helium bottle to approximately 10 to 25 psig, adjusting the pressure so as to bleed helium through the charging line. Allow the gas to flow freely around the flare fitting for 30 seconds to purge the charging line of air. Then tighten the flare nut at the end of the charging line while the helium is flowing at 10 to 25 psig.

(4) Reset the regulator to 300 psig. Slowly open the helium charge valve on the rear of the compressor unit and allow the pressure to gradually rise to 250 psig if the high-vacuum pump is not in operation and is at ambient temperature. If the high-vacuum pump is in operation, on the other hand, allow the pressure to gradually rise to 285 psig.

> Note: Use the supply pressure gauge on the rear of the compressor unit to set the charge pressure -- NOT the gauge at the regulator.

(5) Tightly close the helium charge valve on the compressor unit.

(6) Shut off the pressure regulator, and remove the charging line from the male flare fitting.

(7) Reinstall the flare cap on the male flare fitting.

6.4 DECONTAMINATION PROCEDURES

The decontamination procedures given in Sections 6.4.1 and 6.4.2 are to be used for decontaminating the helium-gas circuits of the cold head and the compressor unit of the CRYO-TORR(R) 8 High-Vacuum Pump.

One of the major sources of helium contamination in CRYO-TORR high-vacuum pumps is the use of helium gas that is of insufficient purity. Helium gas of at least 99.999% purity should be used when decontaminating CRYO-TORR high-vacuum pumps. The helium gas that is typically available for helium-leak detection or welding purposes may not be of sufficient purity and therefore should NOT be used in a CRYO-TORR high-vacuum pump. Such gas may contain impurities (chiefly nitrogen, neon, and water vapor) to the extent that they will accumulate within the cold regions of the cold head and lead to a reduction in the performance of the CRYO-TORR high-vacuum pump.

Contamination of the helium-gas circuits of a CRYO-TORR high-vacuum pump will usually be indicated by sluggish or intermittent operation (ratchetting) of the cold-head drive mechanism. Such operation will be accompanied by warming of the condensing and adsorbing arrays (as revealed by an increase in the indicated operating temperature of the cold head) and may also affect the vacuum in the User's vacuum system. In severe cases of contamination, the cold-head drive mechanism will seize and fail to operate. Such a failure is caused by a large quantity of contaminants freezing in the cold head.

The decontamination procedure given in Section 6.4.1 should be used to clean up the cold head and thereby restore its performance. It is important to note that the cold-trapping of the contaminants inside the cold head that occurs during that procedure also serves to satisfactorily purify the compressor unit whenever the level of contamination within the helium-gas circuits of the CRYO-TORR high-vacuum pump is not severe.

The decontamination procedure given in Section 6.4.2 should be used to clean up the compressor unit whenever (a) maintenance has been performed on the helium-gas circuit of the compressor unit or (b) it is suspected that the compressor unit has become severely contaminated during operation of the CRYO-TORR high-vacuum pump.

> Note: Routine replacement of the compressor-unit adsorber does not contaminate the compressor unit. As shipped, each replacement adsorber is charged with helium gas and is provided with self-sealing couplings that enable installation without contamination of the helium-gas charge.

CTI-CRYOGENICS recommends that the User not employ evacuation to decontaminate either the cold head or the compressor unit (because special equipment and procedures are required).

If the User does, however, choose to evacuate either the cold head or the compressor unit, permanent damage may result to the component concerned if it is turned on while it is being evacuated by a mechanical pump. In particular, operating either the cold-head drive motor or the compressor-pump motor under a vacuum may destroy the motor (due to the low dielectric strength of helium in the 50-millitorr range). This is but one of several problems that may result from decontamination by evacuation.

6.4.1 Decontaminating the Cold Head

If for any reason, it is suspected that the helium gas in the cold head of a CRYO-TORR(R) 8 High-Vacuum Pump has become contaminated, proceed as follows to clean up the cold head.

> Note: For this procedure, the appropriate evacuation and charging adapter must be employed. Use the evacuation and charging adapter that can be ordered as CTI-CRYOGENICS part number D8032051.
>
> *CAUTIONS: (1) WHEN CONNECTING OR DISCONNECTING A SELF-SEALING COUPLING, ALWAYS USE TWO WRENCHES. THIS IS TO AVOID LOOSENING THE BODY OF THE COUPLING FROM ITS ADAPTER.*
>
> *(2) ALWAYS CHECK THAT THE FLAT RUBBER GASKET IS IN PLACE BEFORE CONNECTING A SELF-SEALING COUPLING.*
>
> *(3) IF THE COLD HEAD STARTS TO RATCHET DURING STEP 1 BELOW, PROCEED IMMEDIATELY TO STEP 2.*

(1) Cool down the CRYO-TORR high-vacuum pump and operate it for at least one hour (preferably three hours if possible).

> Note: As a result of this step, the contaminants in the helium-gas circuits of the high-vacuum pump tend to become frozen inside the cold head, and thereby become trapped inside the cold head. The longer the high-vacuum pump is operated beyond the one-hour period, the greater is the amount of contamination that becomes isolated inside the cold head.

(2) Shut down the CRYO-TORR high-vacuum pump.

(3) IMMEDIATELY disconnect the helium return and supply lines from the gas-return and gas-supply connectors at the rear of the compressor unit, but leave them attached at the cold head.

> Notes: (1) It is imperative that the interconnecting lines be disconnected IMMEDIATELY after shutdown so that contamination can not migrate back into the compressor unit.

(2) If the interconnecting lines have NOT been disconnected IMMEDIATELY after shutdown, then the high-vacuum pump should be restarted to once again cool down the cold head in accordance with step 1. Steps 2 and 3 should then be performed.

(4) Attach the evacuation and charging adapter to the disconnected ends of the helium return and supply lines.

CAUTION: IN THE FOLLOWING STEP, DO NOT REDUCE THE PRESSURE BELOW 30 PSIG. TO DO SO MAY RESULT IN THE INTRODUCTION OF ADDITIONAL CONTAMINATION INTO THE COLD HEAD.

(5) Reduce the pressure in the cold head to a level of 30 psig by using the evacuation and charging adapter.

(6) Allow 4 hours for the second stage of the cold head to warm up to room temperature.

CAUTION: THE COLD-HEAD SECOND STAGE MUST BE AT ROOM TEMPERATURE BEFORE STEP 7 IS COMMENCED. OTHERWISE, THE DECONTAMINATION PROCEDURE WILL BE INEFFECTIVE.

Note: The warm-up time can be decreased by:
(a) backfilling the vacuum housing of the cryopump to one atmosphere with dry argon or nitrogen gas, and/or
(b) wrapping a heating tape around the vacuum housing of the cryopump.

CAUTION: DO NOT HEAT THE CRYOPUMP ABOVE 150°F (66°C). TO DO SO WILL RESULT IN DAMAGE TO SOME MATERIALS IN THE CRYOPUMP.

(7) Attach a helium bottle, regulator, and charging line to the evacuation and charging adapter and purge the charging line and regulator of air.

CAUTION: DO NOT USE HELIUM GAS THAT IS LESS THAN 99.999% PURE.

Note: After the regulator has been installed on the helium bottle but before the bottle valve has been opened, it is important that the adjusting screw on the regulator be turned clockwise until the regulator is open. Then open the valve on the bottle and immediately back off on the regulator adjusting screw until the helium stops flowing. This procedure is required in order that both the regulator and the charging line will be purged and the air trapped in the regulator will not diffuse into the bottle.

(8) Perform the following sequence of steps (a) through (d):

(a) Pressurize the cold head with helium to within +0, -5 psig tolerance of 250 psig, the static charge pressure.

Note: This pressure range is valid when the cold head is at nominal room temperature (59°F to 77°F; 15°C to 25°C).

(b) Depressurize the cold head to 30 psig.

(c) Perform flushing steps (a) and (b) four more times.

(d) Pressurize the cold head to within +0, -5 psig of the 250-psig static charge pressure and run the cold-head drive motor for 10 to 30 seconds by means of the compressor-unit "ON-OFF" switch and the cold-head "ON-OFF" switch.

(9) Perform steps (b) through (d) four more times.

Note: There will be a total of 25 flushes and a total of 5 drive-motor runs.

(10) Verify that the cold head is pressurized to within +0, -5 psig of the 250-psig static charge pressure.

(11) Disconnect the evacuation and charging adapter from the ends of the helium return and supply lines.

CAUTION: CHECK THAT THE FLAT RUBBER GASKETS ARE IN PLACE BEFORE RECONNECTING THE SELF-SEALING COUPLINGS IN STEP 12 BELOW.

(12) Reconnect the helium return and supply lines to the gas-return and gas-supply connectors at the rear of the compressor unit.

(13) Restart the CRYO-TORR high-vacuum pump; see Section 3.3.

6.4.2 Decontaminating the Compressor Unit

When the level of contamination within the helium-gas circuits of the CRYO-TORR(R) 8 High-Vacuum Pump is not severe, the use of the procedure given in Section 6.4.1 will generally decontaminate the compressor unit as well as the cold head. This is because contaminants in the compressor unit will have become isolated inside the cold head during the procedure.

Use the procedure of this section to decontaminate the compressor unit when the following conditions exist.

(a) Maintenance has been performed on the helium-gas circuit of the compressor unit (for example, replacing a filter or an orifice). For this condition, commence the clean-up with step 3 below.

(b) It is suspected that the compressor unit has become severely contaminated during operation of the CRYO-TORR high-vacuum pump. For this condition, commence the clean-up with step 1.

CAUTIONS: (1) WHEN CONNECTING OR DISCONNECTING A SELF-SEALING COUPLING, ALWAYS USE TWO WRENCHES. THIS IS TO AVOID LOOSENING THE BODY OF THE COUPLING FROM ITS ADAPTER.

(2) ALWAYS CHECK THAT THE FLAT RUBBER GASKET IS IN PLACE BEFORE CONNECTING A SELF-SEALING COUPLING.

(1) Shut down the CRYO-TORR high-vacuum pump.

(2) IMMEDIATELY disconnect the helium return and supply lines from the gas-return and gas-supply connectors at the rear of the compressor unit, but leave them attached at the cold head.

Note: To clean up the cold head, which will also have become contaminated, proceed in accordance with steps 4 through 13 of the procedure given in Section 6.4.1.

(3) Perform the following sequence of steps (a) through (e) for compressor-unit decontamination.

(a) Reduce the static pressure of the compressor unit to a level of 30 psig by removing the flare cap from the helium-gas charge fitting at the rear of the compressor unit and opening the helium charge valve while observing the supply pressure gauge.

(b) Attach a helium bottle, regulator, and charging line to the male flare fitting on the helium charge valve and purge the charging line and the regulator of air.

CAUTION: DO NOT USE HELIUM GAS THAT IS LESS THAN 99.999% PURE.

Note: After the regulator has been installed on the helium bottle but before the bottle valve has been opened, it is important that the adjusting screw on the regulator be turned clockwise until the regulator is open. Then open the valve on the bottle and immediately back off on the regulator adjusting screw until helium stops flowing. This procedure is required in order that both the regulator and the charging line will be purged and the air trapped in the regulator will not diffuse into the bottle.

(c) Pressurize the compressor unit with helium to within +0, -5 psig of 250 psig, the static charge pressure.

(d) Perform flushing steps (a) through (c) four more times.

(e) With the compressor unit pressurized to within +0, -5 psig of the 250-psig static charge pressure, run the compressor unit for 1 to 2 minutes.

(4) Perform this sequence of steps (a) through (e) two more times.

Note: There will be a total of 15 flushes and a total of 3 runs of the compressor unit.

(5) Allow the compressor unit to cool to room temperature.

(6) Verify that the compressor unit is pressurized to within +0, -5 psig of the 250-psig static charge pressure.

CAUTION: CHECK THAT THE FLAT RUBBER GASKETS ARE IN PLACE BEFORE RECONNECTING THE SELF-SEALING COUPLINGS IN STEP 7 BELOW.

(7) Reconnect the helium return and supply lines to the gas-return and gas-supply connectors at the rear of the compressor unit.

(8) Restart the CRYO-TORR high-vacuum pump.

Note: As the high-vacuum pump continues to operate, any residual contamination of the compressor unit will become isolated in the cold head and can be readily removed from the cold head by using the procedure given in Section 6.4.1; see step 9 below.

(9) As soon as convenient (but preferably after 48 hours or more of operation), again carry out the procedure given in Section 6.4.1 (starting with step 2), in order to remove the above-noted residual contamination.

6.5 SERVICING THE SELF-SEALING COUPLINGS

The self-sealing couplings employed in the CRYO-TORR(R) 8 High-Vacuum Pump are Aeroquip Type 5400 couplings. The servicing of these couplings is limited to the removal and replacement of gaskets and O-rings. Figure 6-2 shows the structure of Aeroquip Type 5400 couplings.

> Note: Coupling halves, complete with poppet valves, are available from CTI-CRYOGENICS.

Proceed as follows to service a self-sealing coupling.

> Note: It is assumed in the following procedure that the coupling concerned has been properly disconnected by the use of two wrenches; see Section 2.1.

> *WARNING: DO NOT DISASSEMBLE A COUPLING HALF UNTIL THE COMPONENT TO WHICH IT IS CONNECTED HAS BEEN DEPRESSURIZED BY BLEEDING THE HELIUM CHARGE DOWN TO ATMOSPHERIC PRESSURE. USE THE EVACUATION AND CHARGING ADAPTER; SEE SECTION 6.7.*

> *CAUTION: USE TWO WRENCHES WHEN DISASSEMBLING A COUPLING HALF. ONE WRENCH IS REQUIRED TO PREVENT THE ADAPTER FROM TURNING, AND POSSIBLY BREAKING ITS CONNECTION TO THE TUBING, WHILE THE OTHER WRENCH IS BEING USED TO REMOVE THE BODY FROM THE ADAPTER.*

(1) Remove the coupling jam nut and the associated lockwasher from a coupling half if the coupling half is secured to a panel or frame.

(2) Remove the body from the adapter of the coupling half shown at the left side of Figure 6-2.

(3) Remove the gasket from the body, and the O-ring from the adapter. Discard the gasket and the O-ring.

(4) Remove the body from the adapter of the coupling half shown at the right side of Figure 6-2.

(5) Push out the bonded-sleeve-and-stem-valve assembly.

(6) Remove the O-ring from the adapter and discard it.

(7) Thoroughly clean the parts of the two coupling halves.

(8) Sparingly lubricate with vacuum grease a replacement O-ring and gasket, and install them on the coupling half shown on the left side of Figure 6-2.

(9) Lubricate with vacuum grease a replacement O-ring and install it on the coupling half shown on the right side of Figure 6-2.

(10) Using two wrenches (see the caution at the front of Section 6.5), slowly tighten the body of each coupling half to its adapter. The recommended torque values for making this connection are as follows.

1/4-inch coupling size:	15-20 foot-pounds
1/2-inch coupling size:	35-45 foot-pounds

Note: The quarter-inch coupling size is designated by Aeroquip part numbers ending in -4; the half-inch coupling size is designated by part numbers ending in -8.

(11) Decontaminate, in accordance with Section 6.4, the components to which the two coupling halves are connected.

(12) Place one drop of oil (and only one drop) on the external mating threads, and reconnect the two coupling halves. The recommended torque value for making this connection is as follows.

1/4-inch coupling size:	10 foot-pounds
1/2-inch coupling size:	35 foot-pounds

Note: Do not use vacuum grease as a lubricant on the threads.

6.6 EVACUATION AND CHARGING ADAPTER

The evacuation and charging adapter is an optional accessory that is essential as an installation and servicing tool, and is available from CTI-CRYOGENICS. It is recommended that this adapter be purchased because it is useful when installing, maintaining, and recharging components. (As noted in Section 6.4.1, the use of this adapter is required for decontaminating the cold head.) Use CTI-CRYOGENICS part number D8032051 when ordering the adapter. Consult the Product Service Department of CTI-CRYOGENICS for further information regarding its use.

6.7 HAZARDOUS MATERIALS

WARNING: IF A CRYOPUMP IS BEING USED, OR HAS BEEN USED, TO PUMP TOXIC OR DANGEROUS MATERIALS, THE USER MUST TAKE ADEQUATE STEPS TO SAFEGUARD PERSONNEL WORKING WITH THE EQUIPMENT. (THIS IS PARTICULARLY IMPORTANT SHOULD IT BECOME NECESSARY TO DISASSEMBLE THE CONDENSING ARRAYS OF THE CRYOPUMP.) IF SUCH A CRYOPUMP IS SHIPPED TO CTI-CRYOGENICS, IDENTIFY CLEARLY THAT THIS COMPONENT HAS BEEN USED WITH TOXIC OR DANGEROUS MATERIALS.

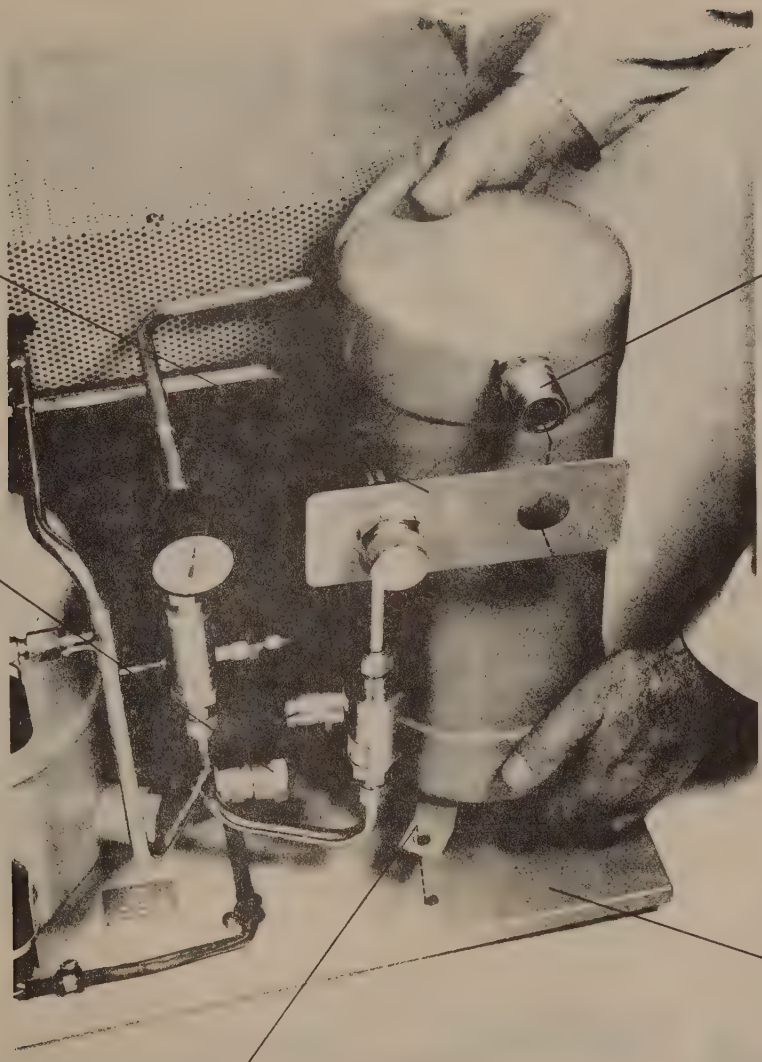

SUPPORT PLATE
STEP 3
REMOVE THE JAM NUT AND WASHER THAT SECURE THE ADSORBER-OUTLET SELF-SEALING COUPLING TO ITS SUPPORT PLATE; THEN, CAREFULLY SLIDE THE ADSORBER INWARD UNTIL THE OUTLET SELF-SEALING COUPLING CLEARS THE SUPPORT PLATE AND REMOVE THE ADSORBER.
STEP 2
DISCONNECT THE ADSORBER-INLET SELF-SEALING COUPLING (SEE FIGURE 6-3)
BASE OF COMPRESSOR UNIT
STEP 1
REMOVE THE BOLTS, NUTS, AND WASHERS THAT SECURE THE ADSORBER TO THE BASE OF THE COMPRESSOR UNIT.

FIGURE 6-1. REMOVING THE ADSORBER FROM THE MODEL 350SC COMPRESSOR UNIT

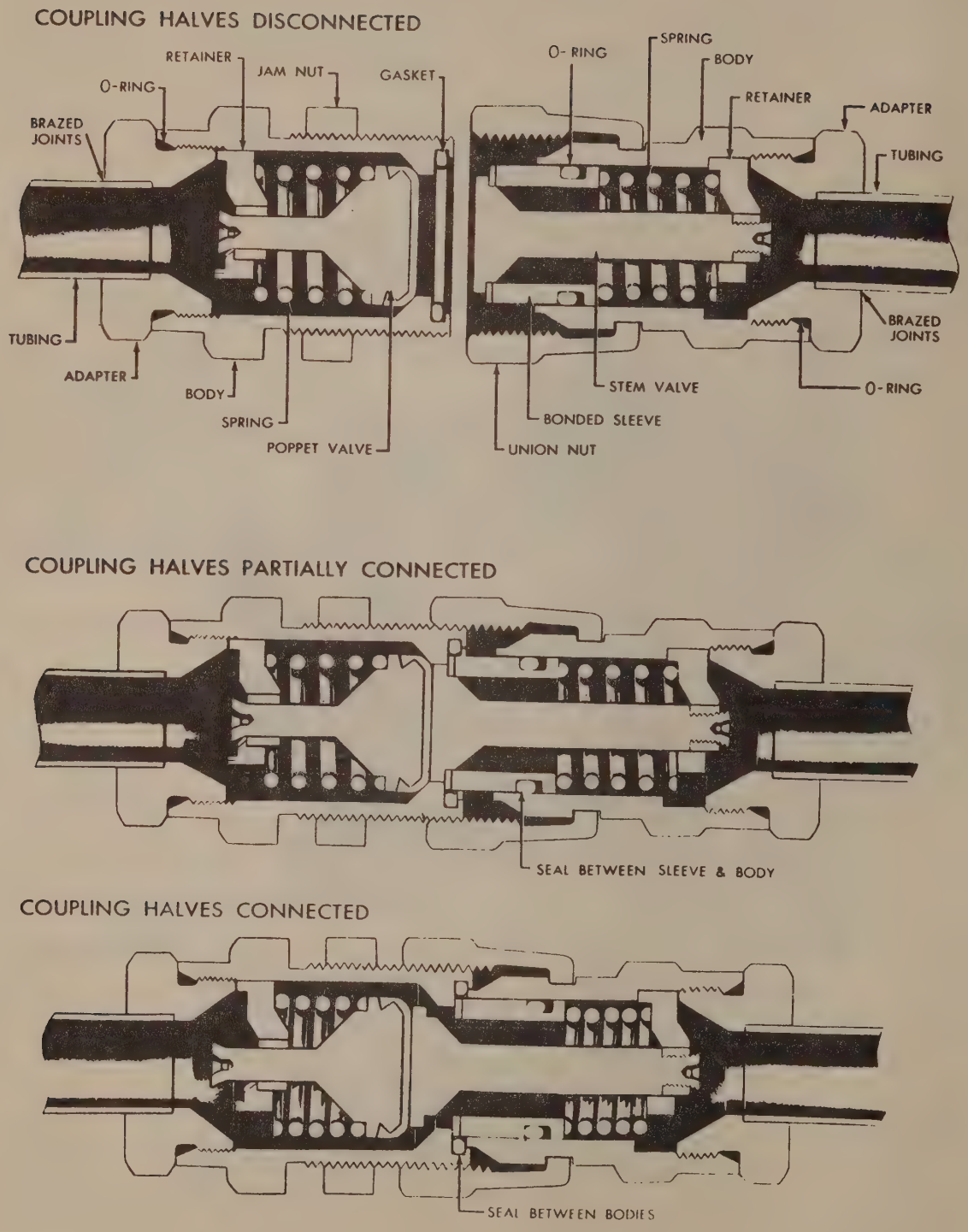


FIGURE 6-2. CUTAWAY VIEWS OF A SELF-SEALING COUPLING (AEROQUIP)

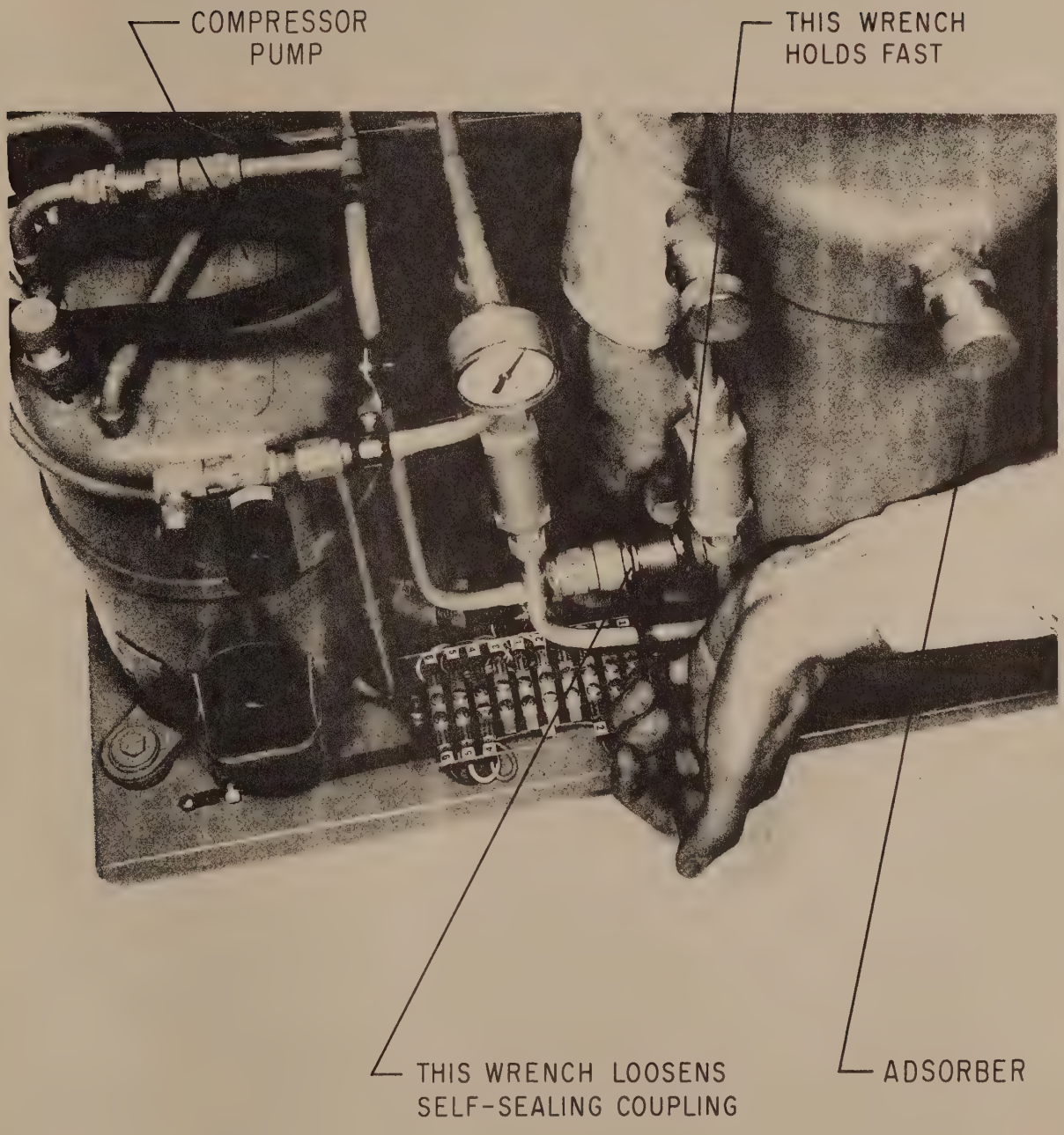


FIGURE 6-3. DISCONNECTING THE ADSORBER-INLET SELF-SEALING COUPLING IN THE MODEL 350SC COMPRESSOR UNIT

APPENDICES

APPENDIX A

ILLUSTRATED PARTS BREAKDOWN FOR THE CRYO-TORR(R) 8 CRYOPUMP

An illustrated parts breakdown is included for the CRYO-TORR 8 Cryopump only (rather than for the complete CRYO-TORR 8 High-Vacuum Pump, which includes the Model 350SC Compressor Unit). This breakdown is provided for the convenience of the User in the event that disassembly beyond the scope of this manual is required (for example, if severe contamination of the cryopump arrays has occurred). Contact the Product Service Department of CTI-CRYOGENICS if further assistance is required.

LEGEND - FIGURE A-1

Item Number	Part Number	Description	No. Req'd
-	E8033047G1	CRYO-TORR(R) 8 Cryopump	1
1	D8033019	80K Array Assembly	1
2	-----	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	4
3	-----	Lockwasher, Split Type, SSTL, #6	4
4	D8033021	15K Array Assembly	1
5	8033020	Inner Charcoal Chamber Assembly*	1
6	-----	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	4
7	-----	Lockwasher, Split Type, SSTL, #6	4
8	-----	Washer, Flat, SSTL, #6	4
9	D8033018	80K Radiation Shield	1
10	-----	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 3/8" Lg.	6
11	-----	Lockwasher, Split Type, SSTL, #6	6
12	-----	Washer, Flat, SSTL, #6	6
13	51-54-43	Portion of the Pressure Relief Valve that can be taken apart for cleaning	1
14	B3996034	Accessory-Port Cover	1
15	-----	O-Ring, #2-20, Viton, Parker V377-9	1
16	-----	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	4
17	-----	Lockwasher, Split Type, SSTL, #6	4
18	-----	Washer, Flat, SSTL, #6	4
19	C8033022	Hydrogen-Vapor-Pressure Gauge Assembly	1
20	-----	O-Ring, #2-20, Viton, Parker V377-9	1
21	-----	Cap Screw, Hexagon Socket Type, SSTL, #6-32 x 1/2" Lg.	4
22	-----	Lockwasher, Split Type, SSTL, #6	4
23	-----	Washer, Flat, SSTL, #6	4
24	-----	Cap Screw, Hexagon Socket Type, SSTL, #2-56 x 1/2" Lg.	2
25	-----	Lockwasher, Split Type, SSTL, #6	2
26	D8033034	Drive Unit - Displacer Assembly	1
27	-----	O-Ring, #2-140, Buna-N, Parker N219-7	1
28	-----	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1/2" Lg.	2
29	-----	Cap Screw, Hexagon Socket Type, SSTL, #10-32 x 1-1/4" Lg.	4
30	C3996022	Protective Cover	1
31	-----	O-Ring, #2-172, Viton, Parker V377-9	1
32	-----	Screw, Hexagon Head, SSTL, 5/16-24 x 5/8" Lg.	4
33	-----	Washer, Flat, SSTL, 3/8"	4
34	E8033016	Vacuum Housing	1
-	50-50-13	Indium Sheet, 3" x 6" x 0.005" thick	1

*Also known as the 15K Cryo-Adsorbing Array Assembly.

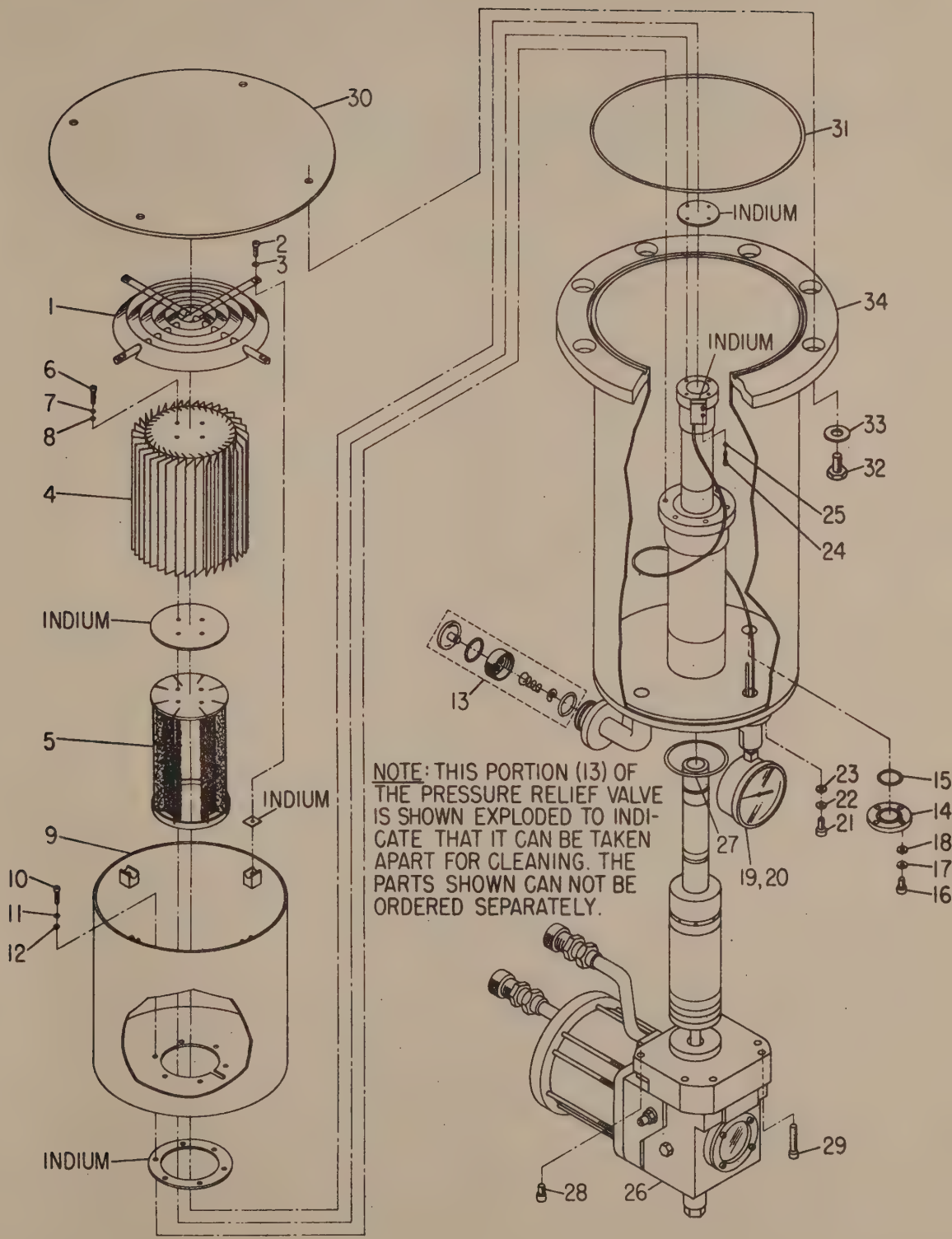
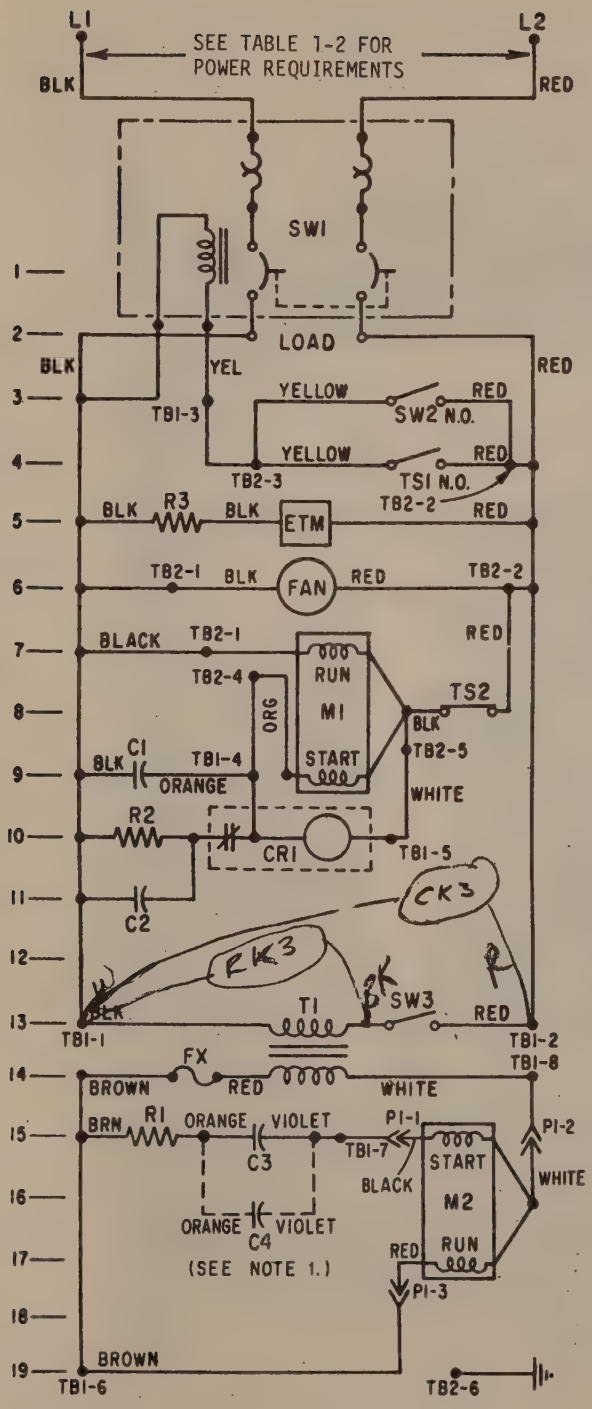


FIGURE A-1 EXPLODED VIEW OF THE CRYO-TORR® 8 CRYOPUMP

APPENDIX B

ELECTRICAL SCHEMATIC AND LOCATION INFORMATION

An electrical schematic (see Figure B-1) and an illustration showing the physical location of electrical-control-chassis components (see Figure B-2) are provided for the convenience of the User in case an electrical problem beyond the scope of this manual should occur.



LEGEND

C1 - COMPRESSOR-RUN PHASE-SHIFTING CAPACITOR - 25 μFD, 440 V
C2 - COMPRESSOR START CAPACITOR - 48 ± 5 μFD, 330 V
C3 - COLD-HEAD-DRIVE-MOTOR PHASE-SHIFTING CAPACITOR - 6 μFD, 330 V
C4 - COLD-HEAD-DRIVE-MOTOR PHASE-SHIFTING CAPACITOR - 2 μFD, 330 V (FOR 50-Hz OPERATION ONLY)
CR1 - COMPRESSOR STARTING RELAY
ETM - ELAPSED-TIME METER
FAN - COOLING FAN
FX - COLD-HEAD CIRCUIT FUSE-1 AMP
M1 - COMPRESSOR PUMP MOTOR
M2 - COLD-HEAD DRIVE MOTOR
P1 - COLD-HEAD CABLE CONNECTOR
R1 - COLD-HEAD-DRIVE-MOTOR PHASE-SHIFTING RESISTOR - 150 Ω
R2 - COMPRESSOR START RESISTOR - 18K Ω
R3 - BALLAST RESISTOR FOR ELAPSED TIME METER - 13K Ω
SW1 - COMPRESSOR "ON-OFF" SWITCH
SW2 - SAFETY INTERLOCK SWITCH
SW3 - COLD-HEAD "ON-OFF" SWITCH
T1 - COLD-HEAD ISOLATION TRANSFORMER 140-168 V OUTPUT
TB1 - TERMINAL BOARD (CHASSIS)
TS1 - THERMAL PROTECTIVE SWITCH
TS2 - OVERCURRENT PROTECTIVE SWITCH
TB2 - TERMINAL BOARD (COMPRESSOR)

NOTES:

1. C4 IS FOR 50-Hz OPERATION ONLY.
2. TERMINAL-BOARD MECHANICAL LINKAGES ARE AS FOLLOWS:

TB1-1 > TB2-1
TB1-1 > TB2-1
TB1-2 > TB2-2
TB1-2 > TB2-2
TB2-2
TB2-3
TB2-3

FIGURE B-1. ELECTRICAL SCHEMATIC FOR THE MODEL 350SC COMPRESSOR UNIT

LEGEND - FIGURE B-2

Item Number	Description	Symbol Designation
1	1.0 Ampere Fuse	FX
2	Terminal Board No. 1	TB1
3	Compressor-Unit "ON-OFF" Switch	SW1
4	Cold-Head "ON-OFF" Switch	SW3
5	Step-down Transformer	T1
6	Elapsed Time Meter	ETM
7	13K-ohm, 2-watt Resistor	R3
8	Compressor-Unit Start Relay	CR1
9	6-microfarad Capacitor	C3
10	18K-ohm, 2-watt Resistor (see Note 2)	R2
11	25-microfarad Capacitor	C1
12	150-ohm, 50-watt Resistor	R1
13	2-microfarad Capacitor (see Note 3)	C4
14	48 $\pm$ 5 microfarad Capacitor	C2

Notes: (1) See Figure B-1 for the location of these items in the electrical circuit for the electrical-control chassis.

(2) Resistor R2 is located on the front of capacitor C2 and is not visible in Figure B-2.

(3) Capacitor C4 is present only in a compressor unit that is designed for 50-Hz operation.

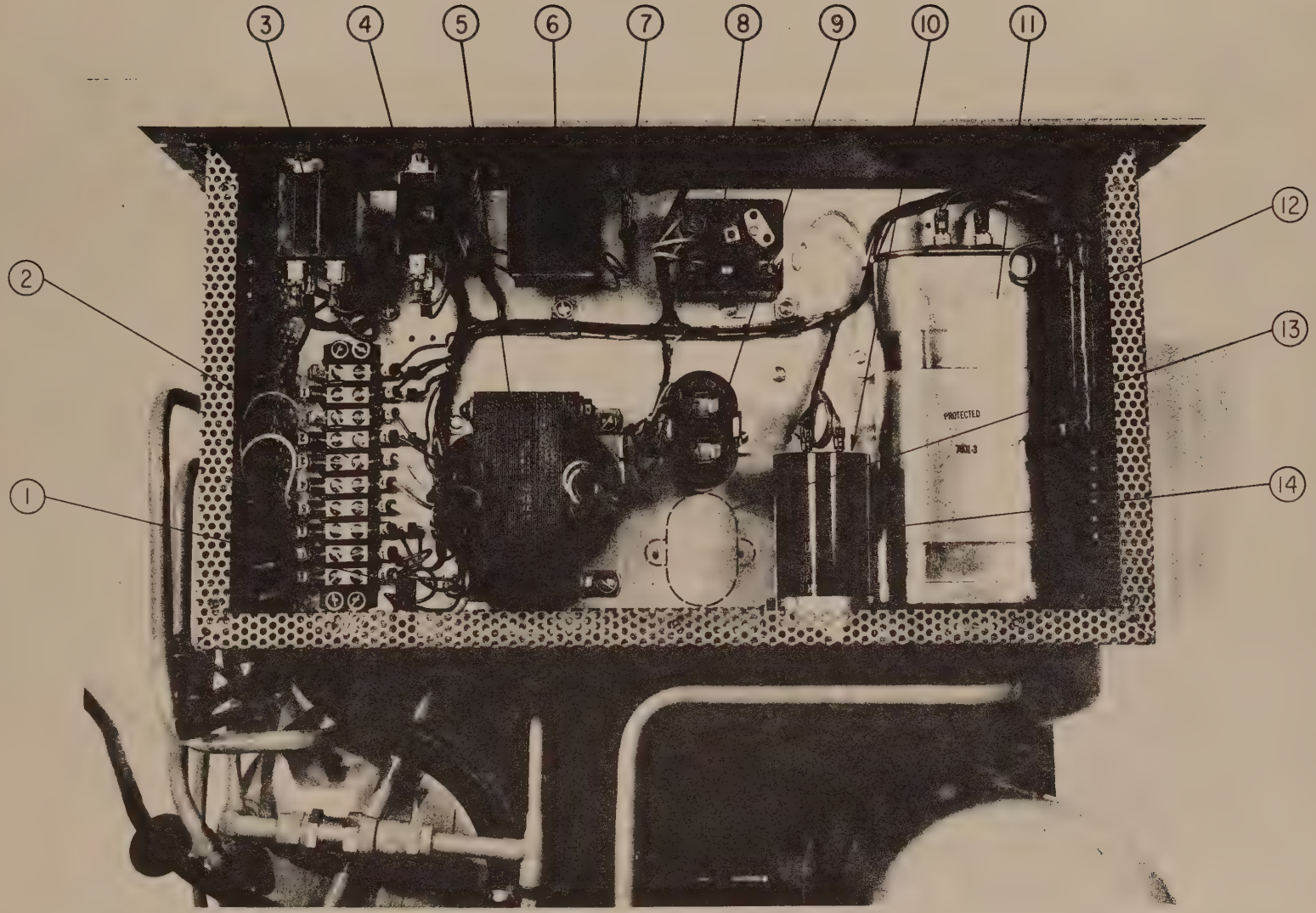


FIGURE B-2 COMPONENTS IN THE ELECTRICAL-CONTROL CHASSIS OF THE MODEL 350SC COMPRESSOR UNIT

APPENDIX C

EQUIPMENT LIST FOR THE CRYO-TORR(R) 8 HIGH-VACUUM PUMP

Item Number	Quantity	Part Number	Description
1	1	E8033047G1	CRYO-TORR(R) 8 Cryopump
2	1	*	350SC Compressor Unit
3	2	D3592252P20	Flexible Interconnecting Piping
4	1	8032040G4	Installation Tool Kit (see Appendix D)
5	1	58-64-41	O-Ring, #2-172, Viton, Parker V377-9
6	1	M8040003	Installation, Operation, and Servicing Instructions for the CRYO-TORR 8 High-Vacuum Pump
		*D8032028G1	350SC Compressor Unit (60 Hz)
		D8032028G2	350SC Compressor Unit (50 Hz)

OPTIONAL ITEM

1	8032051	Evacuation and Charging Adapter

APPENDIX D

INSTALLATION TOOL KIT (KIT NO. 8032040G4)

Item Number	Quantity	Description
1	1	1-inch open-end wrench, Armstrong, for self-sealing coupling
2	1	1 1/8-inch open-end wrench, Armstrong, for self-sealing coupling
3	1	1 3/16-inch open-end wrench, Armstrong, for self-sealing coupling
4	1	7/64-inch Hex ball-end speed wrench, Bondhus BS 7/64
5	4	Gasket seal, Aeroquip 22008-8, for self-sealing coupling
6	1	Fuse, 250 volts, 1 ampere, Buss MDL-1
7	1	Indium sheet 3" x 3" x 0.005"

APPENDIX E

PRINCIPLES OF OPERATION

The following Technical Data sheet explains the principles of operation by which the cold head and compressor unit employed in the CRYO-TORR(R) 8 High-Vacuum Pump achieve cryogenic levels of refrigeration.

TECHNICAL DATA CRYODYNE® CLOSED-CYCLE HELIUM REFRIGERATORS

The cooling process (cycle) of CRYODYNE Helium Refrigerators is analogous to that of common household refrigerators. In the latter, a working fluid (freon gas) is compressed, the heat of compression removed by air-cooled heat exchangers, and the gas is then expanded to produce cooling below the ambient temperature. This simple compression-expansion process will suffice for the household refrigerator, where temperatures in the sub-zero fahrenheit range are required. However, CRYODYNE systems must operate effectively and routinely at temperatures down to 4.2 K (−452°F). Attainment of such extreme low levels requires highly efficient heat exchangers, and the use of a working fluid (helium gas) that remains fluid at temperatures approaching absolute zero (−459.6°F, −273.1°C, 0 K).

All CRYODYNE systems comprise a standard, air-cooled, oil-lubricated compressor unit with oil separation system (carry-over oil vapors would solidify at cyrogenic temperatures and plug the heat exchangers of the refrigerator); and a refrigerator unit (remotely located from the compressor), which operates at slow speeds,

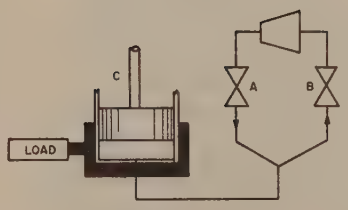


Figure 1 Elementary Cooling Circuit

has ample clearances, and has room-temperature valves and seals.

The flow of helium in the refrigerator is cyclic. The sequence of operations can be illustrated by a single cylinder and piston (Figure 1).

A source of compressed gas is connected to the bottom of cylinder C through inlet valve A. Valve B is in the exhaust line leading to the low-pressure side of the compressor. With the piston at the bottom of the cylinder, and with valve B (exhaust) closed and valve A (inlet) open, the piston is caused to move upward and the cylinder fills with compressed gas. When valve A is closed and valve B is opened, the gas expands into the low-pressure discharge line and cools. The resulting temperature gradient across the cylinder wall causes heat to flow from the load into the cylinder. As a result, the gas warms to its original temperature. With valve B opened, and valve A closed, the piston is then lowered, displacing the remaining gas into the exhaust line, and the cycle is completed.

This elementary system, while workable, would not produce the extreme low temperatures required for uses to which the CRYODYNE refrigerators are applied. Thus the

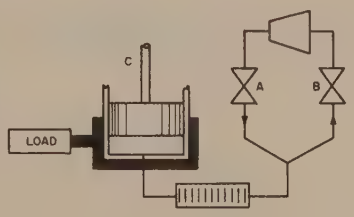


Figure 2 Cooling Circuit with Regenerator

incoming gas must be cooled with the exhaust gas before the former reaches the cylinder. This is accomplished in the CRYODYNE refrigerator by a regenerator, which extracts heat from the incoming gas, stores it, and then releases it to the exhaust stream (Figure 2).

A regenerator is a reversing-flow heat exchanger through which the helium passes alternatively in either direction. It is packed with a material of high surface area, high specific heat, and low thermal conductivity, that will readily accept heat from the helium (if the helium's temperature is higher) and give up this heat to the helium (if the helium's temperature is lower).

In steady-state operation, a system of this type exhibits the characteristic temperature profile of Figure 3. The steps of the cycle are as follows:

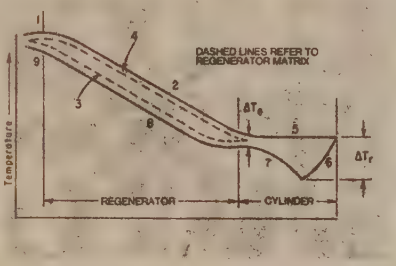


Figure 3 Temperature Profile of a Single-Stage Cryodyne Refrigerator

a. With the piston at the bottom of its stroke, compressed gas enters through valve A at room temperature (1).
b. As the piston rises, the gas passes through the regenerator. The matrix absorbs heat from the gas (warming from 3 to 4), and the gas cools.
c. Still at inlet pressure, the cooled gas fills the space beneath the piston. The gas temperature at this point (5) is about the same as that of the load.
d. Valve A closes and exhaust valve B opens, allowing the gas to expand and cool further as it does so (6). The temperature drop (ΔT_r) is responsible for the refrigerating effect.
e. Heat flows from the load through the cylinder walls, warming the gas to a temperature slightly (ΔT_e) below that at which it entered the cylinder (7).
f. As the gas passes through the regenerator, it warms up (8) as it receives heat from the matrix, and the matrix is cooled (4) to (3).
g. The piston descends, pushing the remaining cold gas out of the cylinder and through the regenerator. However, because the regenerator is not 100 percent efficient, there is always a temperature difference between the gas and the matrix; thus, at any point shown in the diagram, the exhaust gas remains slightly cooler than the inlet gas.
h. The low-pressure gas leaves through valve B at approximately room temperature (9).

In the system of Figure 2, the piston would require a pressure seal and would have to be designed to withstand unbalanced forces. A more practical version of this cycle is shown in Figure 4. This system uses a double-

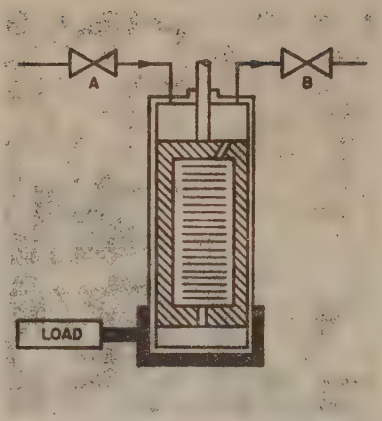


Figure 4 Improved Single Stage Refrigerator

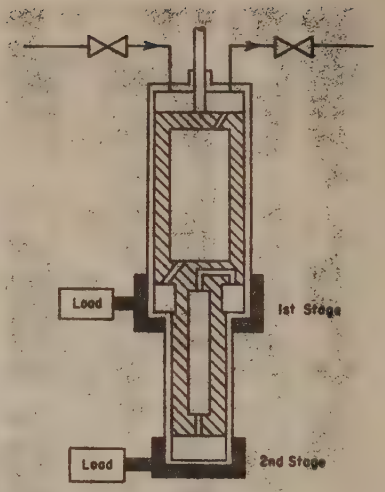


Figure 5 Two-Stage Cryodyne Refrigerator

ended cylinder and an elongated piston made from a material of low thermal conductivity.

Since the pressures above and below the piston are substantially equal, the piston needs no pressure seal. The piston is now more correctly called a "displacer," because it merely moves gas from one end of the cylinder to the other; no mechanical work is introduced, and thus the system is said to use a "no-work" cycle. The regenerator is placed inside the displacer to avoid unnecessary piping and to minimize heat losses.

The refrigerator shown in Figure 4 can achieve temperatures in the 30–77 K range. Since many of the applications of the CRYODYNE refrigerator are below that temperature, we can add a second, and even a third stage to produce temperatures below 10 K.

The addition of a second stage (Figure 5) permits useful refrigeration down to 10 K.

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HELIX

APPENDIX F

CONVERSION OF HYDROGEN-VAPOR-PRESSURE-GAUGE READINGS TO TEMPERATURE

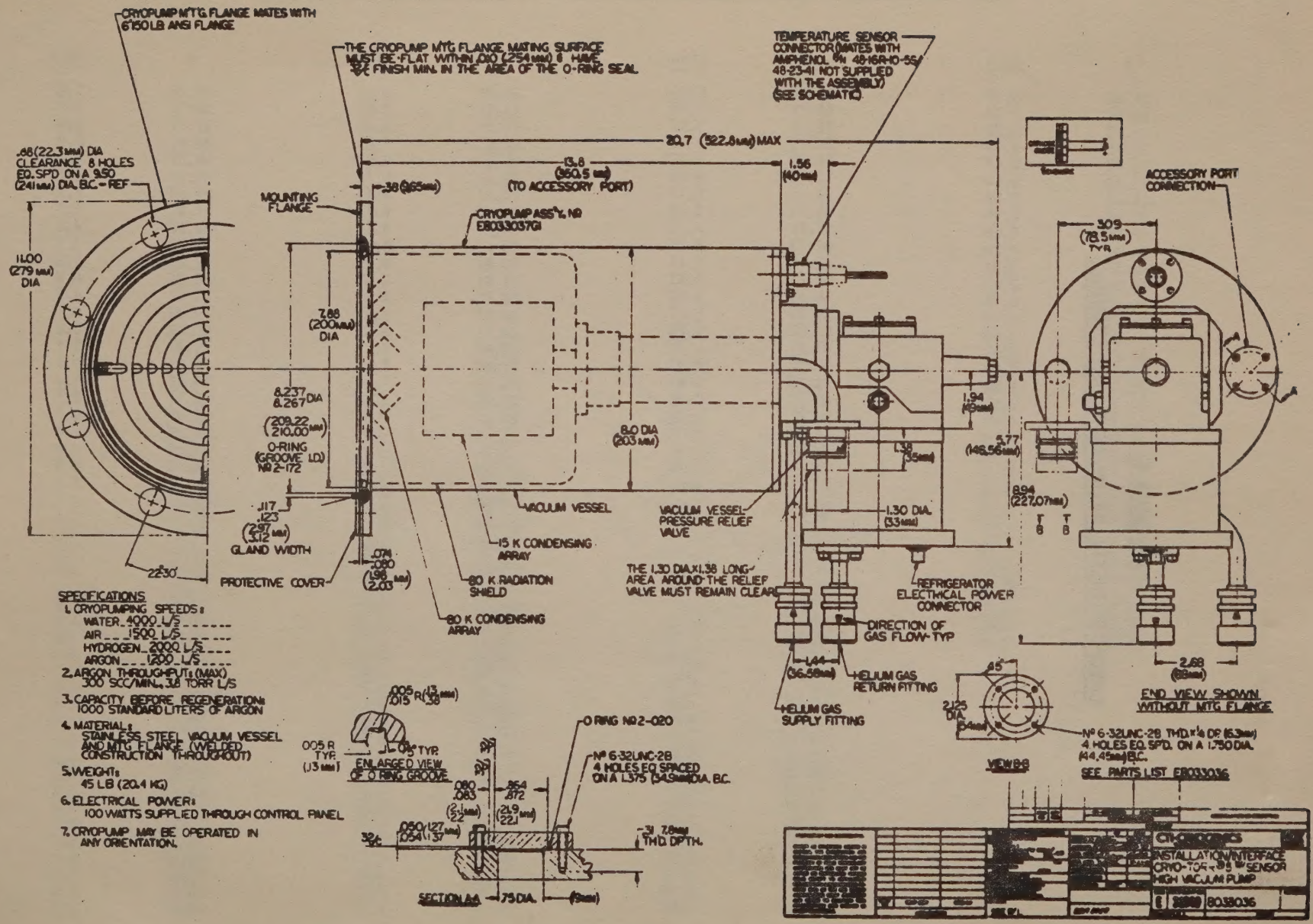
Use the data given in Table F-1 to convert a reading of the hydrogen-vapor-pressure gauge (in psia) to the temperature of the second-stage cold station (in degrees Kelvin).

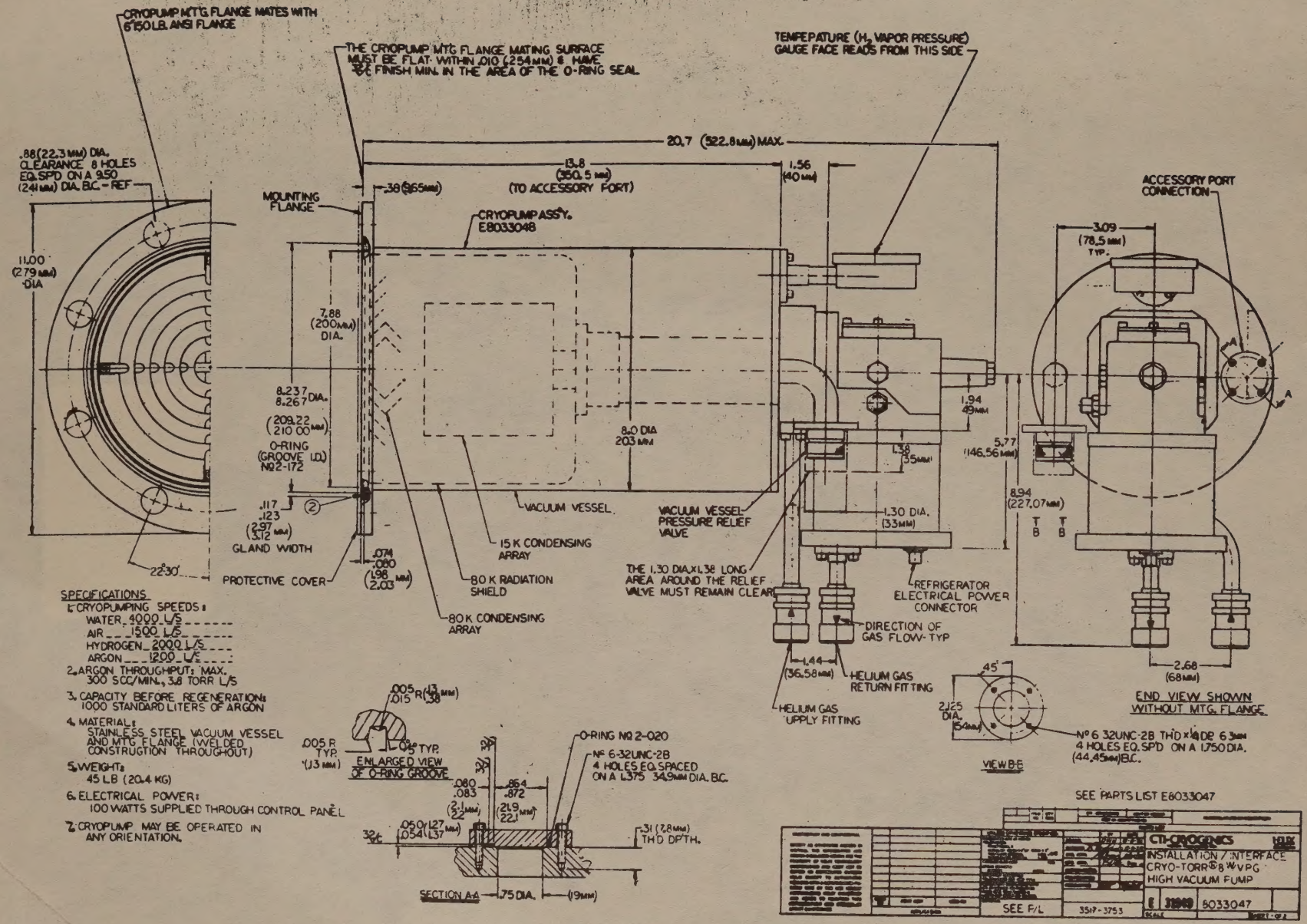
TABLE F-1. TEMPERATURE VS. HYDROGEN-VAPOR-PRESSURE-GAUGE READINGS

PSIA	K	PSIA	K	PSIA	K	PSIA	K
0.2	11.76	10.0	19.15	19.8	21.44	41.0	24.40
0.4	12.60	10.2	19.21	20.0	21.47	41.5	24.46
0.6	13.15	10.4	19.27	20.2	21.51	42.0	24.51
0.8	13.56	10.6	19.33	20.4	21.55	42.5	24.57
1.0	13.89	10.8	19.39	20.6	21.58	43.0	24.62
1.2	14.20	11.0	19.45	20.8	21.62	43.5	24.67
1.4	14.48	11.2	19.50	21.0	21.65	44.0	24.73
1.6	14.73	11.4	19.56	21.2	21.69	44.5	24.78
1.8	14.96	11.6	19.61	21.4	21.72	45.0	24.83
2.0	15.17	11.8	19.67	21.6	21.76	45.5	24.88
2.2	15.36	12.0	19.72	21.8	21.79	46.0	24.93
2.4	15.54	12.2	19.77	22.0	21.83	46.5	24.98
2.6	15.71	12.4	19.83	22.5	21.91	47.0	25.03
2.8	15.87	12.6	19.88	23.0	22.00	47.5	25.08
3.0	16.02	12.8	19.93	23.5	22.08	48.0	25.13
3.2	16.17	13.0	19.98	24.0	22.16	48.5	25.18
3.4	16.31	13.2	20.03	24.5	22.24	49.0	25.23
3.6	16.44	13.4	20.08	25.0	22.32	49.5	25.28
3.8	16.56	13.6	20.13	25.5	22.40	50.0	25.33
4.0	16.69	13.8	20.18	26.0	22.47	50.5	25.37
4.2	16.80	14.0	20.22	26.5	22.55	51.0	25.42
4.4	16.92	14.2	20.27	27.0	22.62	51.5	25.47
4.6	17.03	14.4	20.32	27.5	22.70	52.0	25.52
4.8	17.13	14.6	20.36	28.0	22.77	52.5	25.56
5.0	17.23	14.8	20.41	28.5	22.84	53.0	25.61
5.2	17.33	15.0	20.46	29.0	22.91	53.5	25.65
5.4	17.43	15.2	20.50	29.5	22.98	54.0	25.70
5.6	17.52	15.4	20.55	30.0	23.05	54.5	25.75
5.8	17.62	15.6	20.59	30.5	23.12	55.0	25.79
6.0	17.71	15.8	20.63	31.0	23.19	55.5	25.83
6.2	17.79	16.0	20.68	31.5	23.26	56.0	25.88
6.4	17.88	16.2	20.72	32.0	23.32	56.5	25.92
6.6	17.96	16.4	20.76	32.5	23.39	57.0	25.97
6.8	18.04	16.6	20.80	33.0	23.45		
7.0	18.12	16.8	20.85	33.5	23.52		
7.2	18.20	17.0	20.89	34.0	23.58		
7.4	18.28	17.2	20.93	34.5	23.64		
7.6	18.35	17.4	20.97	35.0	23.70		
7.8	18.43	17.6	21.01	35.5	23.77		
8.0	18.50	17.8	21.05	36.0	23.83		
8.2	18.57	18.0	21.09	36.5	23.89		
8.4	18.64	18.2	21.13	37.0	23.95		
8.6	18.71	18.4	21.17	37.5	24.00		
8.8	18.77	18.6	21.21	38.0	24.06		
9.0	18.84	18.8	21.25	38.5	24.12		
9.2	18.90	19.0	21.28	39.0	24.18		
9.4	18.97	19.2	21.32	39.5	24.24		
9.6	19.03	19.4	21.36	40.0	24.29		
9.8	19.09	19.6	21.40	40.5	24.35		

APPENDIX G

CRYOPUMP INSTALLATION/INTERFACE DRAWINGS


CRYOPUMP MTG. FLANGE MATES WITH 6" 150 LB ANSI FLANGE
THE CRYOPUMP MTG. FLANGE MATING SURFACE MUST BE FLAT WITHIN .010 (.254 mm) & HAVE 32 µ FINISH MIN. IN THE AREA OF THE O-RING SEAL
TEMPERATURE SENSOR CONNECTOR (MATES WITH AMPHENOL P/N 48-16R-10-5S/ 48-23-41 NOT SUPPLIED WITH THE ASSEMBLY) (SEE SCHEMATIC)
.68 (22.3 mm) DIA CLEARANCE 8 HOLES EQ. SPD ON A 9.50 (241 mm) DIA. B.C. - REF
MOUNTING FLANGE
CRYOPUMP ASS'Y. NO E8033037G1
20.7 (522.8 mm) MAX
13.8 (350.5 mm) (TO ACCESSORY PORT)
1.56 (40 mm)
.38 (9.65 mm)
ACCESSORY PORT CONNECTION
11.00 (279 mm) DIA
7.88 (200 mm) DIA
8.237 8.267 DIA (209.22 210.00 mm)
O-RING (GROOVE I.D.) NO 2-172
8.0 DIA (203 mm)
3.09 (78.5 mm) TYP
1.94 (49 mm)
5.77 (146.56 mm)
1.38 (35 mm)
8.94 (227.07 mm)
1.30 DIA. (33 mm)
.117 .123 (2.97 3.12 mm) GLAND WIDTH
.074 .080 (1.96 2.03 mm)
PROTECTIVE COVER
VACUUM VESSEL
15 K CONDENSING ARRAY
80 K RADIATION SHIELD
80 K CONDENSING ARRAY
VACUUM VESSEL PRESSURE RELIEF VALVE
THE 1.30 DIA X 1.38 LONG AREA AROUND THE RELIEF VALVE MUST REMAIN CLEAR
REFRIGERATOR ELECTRICAL POWER CONNECTOR
DIRECTION OF GAS FLOW - TYP
1.44 (36.58 mm)
HELIUM GAS RETURN FITTING
HELIUM GAS SUPPLY FITTING
2.68 (68 mm)
END VIEW SHOWN WITHOUT MTG. FLANGE
2.25 DIA (54 mm)
No 6-32 UNC-2B THD. 1/8 DP (6.3 mm) 4 HOLES EQ. SPD. ON A 1.750 DIA. (44.45 mm) B.C.
SEE PARTS LIST E8033036
VIEW BB
22°30'
.005 R (.13 mm) .015 (.38)
.005 R TYP. (.13 mm)
45° TYP.
ENLARGED VIEW OF O RING GROOVE
O RING NO 2-020
No 6-32 UNC-2B 4 HOLES EQ SPACED ON A 1.375 (34.9 mm) DIA. B.C.
.080 .083 (2.1 2.2 mm)
.854 .872 (21.9 22.1 mm)
.050 (1.27 mm) .054 (1.37 mm)
32 µ
.31 7.8 mm THD. DPTH.
SECTION AA
.75 DIA. (9 mm)
SPECIFICATIONS
1. CRYOPUMPING SPEEDS:
WATER - 4000 L/S
AIR - 1500 L/S
HYDROGEN - 2000 L/S
ARGON - 1200 L/S
2. ARGON THROUGHPUT: (MAX) 300 SCC/MIN., 3.8 TORR L/S
3. CAPACITY BEFORE REGENERATION: 1000 STANDARD LITERS OF ARGON
4. MATERIAL: STAINLESS STEEL VACUUM VESSEL AND MTG. FLANGE (WELDED CONSTRUCTION THROUGHOUT)
5. WEIGHT: 45 LB (20.4 KG)
6. ELECTRICAL POWER: 100 WATTS SUPPLIED THROUGH CONTROL PANEL
7. CRYOPUMP MAY BE OPERATED IN ANY ORIENTATION.
CTI-CRYOGENICS
INSTALLATION/INTERFACE
CRYO-TORR 8 SENSOR
HIGH VACUUM PUMP
8033036


CRYOPUMP MTG. FLANGE MATES WITH 6" 150 LB. ANSI FLANGE
THE CRYOPUMP MTG. FLANGE MATING SURFACE MUST BE FLAT WITHIN .010 (.254MM) & HAVE 32 FINISH MIN. IN THE AREA OF THE O-RING SEAL.
TEMPERATURE (H2 VAPOR PRESSURE) GAUGE FACE READS FROM THIS SIDE
20.7 (522.8MM) MAX.
13.8 (350.5 MM) (TO ACCESSORY PORT)
1.56 (40 MM)
.88 (22.3 MM) DIA. CLEARANCE 8 HOLES EQ. SPD ON A 9.50 (241 MM) DIA. B.C. - REF
MOUNTING FLANGE
.38 (9.65MM)
CRYOPUMP ASSY. E8033048
ACCESSORY PORT CONNECTION
3.09 (78.5 MM) TYP.
11.00 (279 MM) DIA
7.88 (200MM) DIA.
8.237 8.267 DIA. (209.22 210.00 MM)
O-RING (GROOVE I.D.) N°2-172
8.0 DIA 203 MM
1.94 49MM
5.77 (146.56MM)
1.38 35MM
8.94 (227.07MM)
T B T B
.117 .123 (2.97 3.12 MM) GLAND WIDTH
VACUUM VESSEL
VACUUM VESSEL PRESSURE RELIEF VALVE
1.30 DIA. (33MM)
15 K CONDENSING ARRAY
80 K RADIATION SHIELD
80 K CONDENSING ARRAY
PROTECTIVE COVER
.074 .080 (1.98 2.03 MM)
22°30'
THE 1.30 DIA. X 1.38 LONG AREA AROUND THE RELIEF VALVE MUST REMAIN CLEAR
REFRIGERATOR ELECTRICAL POWER CONNECTOR
DIRECTION OF GAS FLOW - TYP
1.44 (36.58MM)
HELIUM GAS RETURN FITTING
HELIUM GAS SUPPLY FITTING
45°
2.25 DIA. (54MM)
2.68 (68MM)
END VIEW SHOWN WITHOUT MTG. FLANGE
VIEW B-B
N° 6-32UNC-2B THD x 1/4 DP. 6.3MM 4 HOLES EQ. SPD ON A 1.750 DIA. (44.45MM) B.C.
.005 R (.13 MM) .015 (.38 MM)
.005 R TYP. (.13 MM)
.05 TYP.
ENLARGED VIEW OF O-RING GROOVE
O-RING N° 2-020
N° 6-32UNC-2B 4 HOLES EQ. SPACED ON A 1.375 34.9MM DIA. B.C.
.080 .083 (2.1 MM)
.864 .872 (21.9 MM 22.1 MM)
.050 (1.27 MM) .054 (1.37 MM)
32 pl.
.31 (7.8MM) THD DP'TH.
SECTION A-A
.75 DIA. (19MM)

SPECIFICATIONS

1. CRYOPUMPING SPEEDS:
   - WATER 4000 L/S
   - AIR 1500 L/S
   - HYDROGEN 2000 L/S
   - ARGON 1200 L/S
2. ARGON THROUGHPUT: MAX. 300 SCC/MIN., 3.8 TORR L/S
3. CAPACITY BEFORE REGENERATION: 1000 STANDARD LITERS OF ARGON
4. MATERIAL: STAINLESS STEEL VACUUM VESSEL AND MTG. FLANGE (WELDED CONSTRUCTION THROUGHOUT)
5. WEIGHT: 45 LB (20.4 KG)
6. ELECTRICAL POWER: 100 WATTS SUPPLIED THROUGH CONTROL PANEL
7. CRYOPUMP MAY BE OPERATED IN ANY ORIENTATION.

SEE PARTS LIST E8033047

		SEE F/L	3517-3753	CTI-CRYOGENICS — INSTALLATION / INTERFACE CRYO-TORR® 8 W/VPG HIGH VACUUM PUMP — E 31989 — 8033047

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